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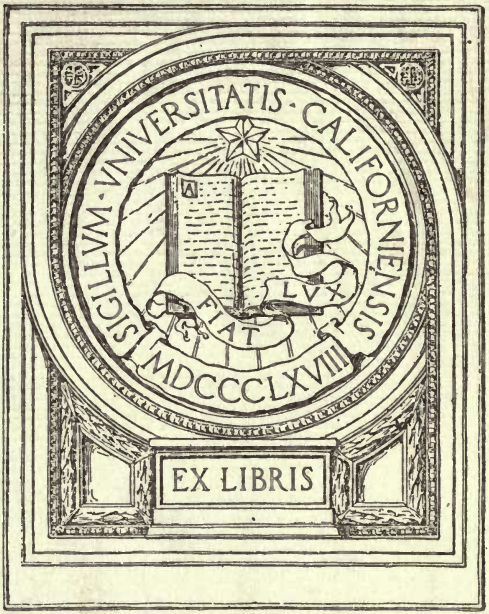

QUESTIONS AND ANSWERS From The Gas Engine

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C. E. P.

PREFACE.

The greatest development of the gas and gasoline engine has been within the last decade. During that time hundreds of skilled mechanics and designers have been devoting their entire energies to the developments of improved designs and improved methods of construction of engines belonging to the internal-combustion type. The most progressive of these men have been readers of THE GAS ENGINE, a magazine devoted to the gas engine industry, which was established in 1898. Many hundreds of them have asked questions which were answered through the columns of the magazine by the best authorities in the gas engine world. Believing that these questions and answers have a permanent value compiled in a separate volume, we have collected the majority of the inquiries and their answers in the present book.

While it has been almost impossible to separate these questions along any well-divided lines, yet an effort has been made to place together those questions of similar nature. For instance, questions which related primarily to trouble with engines are placed together. Theoretical questions of design, formulas, etc., are collected together.

THE GAS ENGINE PUBLISHING CO.

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THEORY OF DESIGN.

(a) Will you kindly state whether in your opinion the two-cycle or the four-cycle gas engine gives the most power? (b) Which style uses the most fuel? (c) What method of governing is considered the best, a hit and miss that opens a valve directly into the cylinder, a hit and miss which opens the exhaust, a throttling governor which controls the supply of gasoline, or a throttling governor which opens a valve directly into the cylinder, allowing fresh air to enter, thereby reducing the strength of the charge? (d) Do you know of any four-cycle engine which can be reversed?

(a) For the same cylinder dimensions the two-cycle engine will give the most power. (b) The four-cycle engine is believed to be the most economical. (c) The method of governing which is the best to use depends entirely upon the purpose for which the engine is employed. If for ordinary machinery, in which small fluctuations in speed are not objectionable. any form of hit and miss governing is good enough, and will usually give the smallest fuel consumption. A throttling governor is usually to be preferred when the motion is required to be very steady as for driving a dynamo or for textile ma-

chinery. The best throttling governor at present in use is one which controls the amount of the mixture that enters the cylinder. (d) We do not know of a four-cycle engine that may be reversed under full speed.

* * *

Is it possible to build a four-cylinder gas engine without a fly wheel and get a satisfactorily running engine?

We believe it to be possible, but do not think it has been done up to the present time. Such an engine would necessitate careful design by an engineer familiar with every phase of the problem.

* * *

Do you know of any gas or gasoline engine that uses spongy platinum to ignite the charge?

We do not know of an engine that employs spongy platinum for the purpose you mention. The idea is by no means a new one, and there are two serious objections to its use. One of these is the comparatively slow action of the platinum to the short time available for the ignition of the charge, and the other is the rapid discoloration of the spongy platinum when used for such a purpose. Our advice is that you employ some good form of electric igniter, as this method is the most satisfactory in the long run, and it is now being adopted by the leading gas-engine builders throughout the country.

Will you kindly inform me if it is practical to use ordinary kerosene for an automobile engine?

That is a problem that is puzzling a number of automobile builders. We believe that the proper line to work on in this problem is to provide a means of heating the oil to a temperature far enough below the flash point to be reasonably safe, and to employ a method of feed that will divide the oil into fine particles, as in an atomizer.

* * *

Should the ignition have any lead in a two-cycle engine?

Yes, sufficient to give the maximum pressure at the beginning of the expansion stroke.

* * *

Is there a rule to determine the point at which the exhaust should open in the different sizes of two-cycle engines?

We know of no empirical formula suited to this case. The point should be so located that the pressure in the cylinder falls below that in the crank-chamber before the inlet port is uncovered.

* * *

Will you kindly inform me what is the best proportion of the stroke of the engine to make the compression space? I have an engine which appears to have an unreasonably large compression space,

and it appears to me that the compression could be increased to advantage.

If there is no clearance beyond that in the cylinder itself, the length of the compression space may be determined by its proportion to the length of the stroke. For the best modern engines the compression space is equal to or less than one-third of the volume displaced by the piston. This means that if all the compression is contained within the cylinder, the length of the compression space is one-quarter that of the stroke. Proper allowance should in every case be made for valve boxes or any other space that is open to the cylinder when the valves are closed. In large engines the increased volume due to the counterbore should also be considered. Before increasing the compression of a gas engine it should be carefully determined if the connecting-rod and the crank-shaft are of sufficient strength to withstand the increase in strain put upon them by the increase in pressure.

* * *

(a) Is it not possible to vary the speed of a gasoline engine by varying the fuel supply? (b) Is it possible to throttle an engine taking gasoline by gravity into the seat of the air valve by controlling the lift of the air valve? (c) May it not be done by altering the stroke of a gasoline pump,

without altering the amount of the air supply in either case?

(a) Yes, within the proper limits. (b) This plan has been tried, but it is not considered a success. (c) See answer to (b).

* * *

(a) May a two-cycle engine be governed by varying the lead of the spark, as is done in a four-cycle engine? (b) Is it customary to fit a governor to a marine engine of four horsepower and over?

(a) Yes. We know of but one builder fitting up marine engines with a governor. (b) Any good governor will answer if properly arranged to suit the engine.

* * *

How is a pneumatic governor constructed?

The pneumatic governor consists of an air pump, a cylinder containing a piston operating against a spring, and a throttling valve connected to the piston. The governor cylinder is fitted with a small orifice, the opening of which can be controlled by a valve. When the speed of the engine rises, air is pumped into the governor cylinder faster than it can escape from the orifice, raising the pressure in the cylinder and moving the piston, thus closing the throttle.

* * *

(a) How hot should air be when used in connection with a vaporizer? (b) Can

it be made too hot? What is the result of overheating the air, and should it be heated at all in the summer time?

(a) Everything depends upon the quality of the fuel and its temperatuure. The proper temperature is best determined by experiment. (b) If the air is too hot there will a smaller quantity enter the cylinder because of the expansion due to rise in temperature. It insures good working to warm the air slightly, even in the summer.

* * *

(a) What is the best form of carbureter to use when the temperature is at 32 deg. F.? (b) If the jacket water is conducted through the carbureter, will the latter work in almost any weather?

(a) There are several good forms, but we believe that the filtering carbureter, in which air is made to pass through a large body of liquid, is the most successful. (b) Yes, if the jacket water is so controlled that it will be at the proper temperature.

* * *

Is the two-cycle engine twice the power of a four-cycle engine of the same dimensions, running at the same speed?

The two-cycle engine is, with the enclosed crank-chamber style of engine, about 1⅞ times the horsepower of the four-cycle. There are two-cycle engines

which give more than twice the power of a four-cycle engine of the same speed and dimensions.

* * *

Will you kindly explain what is meant by the "projected area" of the crank-pin, as mentioned on page 154 of The Gas-Engine Handbook? Does this mean the total area of the pin surface or the slightly less than one-half of the pin surface that is actual contact at one time?

The projected area of any cylindrical surface is found by multiplying the length by the diameter. The projected area means that area which would be projected upon a plane parallel to the axis of the cylinder, by lines drawn from the cylinder to the plane, the lines being perpendicular to the plane.

* * *

Which is the better for operating an automobile engine—a jump-spark or the hammer-break? I am building a small tricycle motor, and am somewhat undecided as to what method I should use. The motor will be 2¼ inches in diameter by 2¾-inch stroke, and will be operated at 1,500 r. p. m.

At all speeds exceeding 800 r. p. m. it is advisable to use the jump-spark method of ignition. For motors running below that speed a great many prefer the hammer-break.

A certain builder of gas engines has the exhaust and inlet ports the same size and the same distance from the top of the cylinder, so that both ports open at the same time. This builder claims that he obtained better results from this arrangement. I should like to have your opinion upon the question.

In the early days of two-cycle practice it was customary to make the top edge of the inlet port even with the bottom edge of the exhaust port. This has lately been reduced to a drop of one-fourth of an inch on an average engine, say of 9 inches by 9 inches. Possibly the builder in question has reason for believing that his engine would operate better than those of other makes by making the drop even. We know of this having been done, but in each case the piston was cut out upon the exhaust side, in order that the exhaust port should be open first, as it is quite universal practice. It is to be feared if both ports are open at the same time, that the hot exhaust gases might fire the fresh charge and cause trouble. The writer has noticed two-cycle engines running without an exhaust pipe attached, and the products of combustion left the engine in a sheet of flame. As the pressure in the cylinder at the moment the exhaust port opens is from six to eight times that in the crank chamber at the same moment,

it is difficult to see what is to prevent the incoming gases from taking fire.

* * *

How do you calculate the amount of time the igniter-electrodes should be in contact before they break?

There is no simple rule that we are aware of for this purpose. The time depends upon the magnetic reluctance of the core of the spark-coil, and this quantity depends in turn upon the quality of the material of which the core is made, and its length.

* * *

What are the advantages of a two-cylinder gas engine over one with a single cylinder?

A two-cylinder engine runs more steadily than an engine with but one cylinder. Three and four-cylinder engines have like advantages over the two-cylinder type.

* * *

(a) What is the initial pressure generated by the explosion of one part air and one part illuminating gas, the mixture filling the cylinder at atmospheric pressure, but compressed to one-third its original volume before ignition? (b) Can the pressure generated be retained in a closed vessel for any length of time, say one-half minute or more?

(a) Between 200 and 240 lbs., according to the quality of the gas. (b) The fall

of pressure depends in a measure upon the rapidity with which the heat can escape from the containing vessel. This fall is very rapid, the return to the pressure before ignition taking less than two seconds. The maximum pressure lasts but a few hundredths of a second in a vessel that has no lagging.

* * *

What is the temperature necessary to insure the ignition of gasoline vapor and also of oil vapor when mixed with air in proportions necessary to produce an explosion?

This question involves the pressure of the mixture and the proportions, and the exact temperature has not, we believe, been accurately determined up to the present writing. We advise the inquirer to experiment in this line under the conditions which surround his particular phase of the problem.

* * *

Please state what rule will give the proper size and weight of flywheels for automobile gas engines.

The following formula will give good results:

Let W=the weight of the flywheel in pounds.

f=the diameter of the flywheel at the center of gravity of the rim in inches.

N=the r. p. m. of the crank-shaft.

$$\text{Then } W = \frac{\text{I. H. P.} \times 334{,}800{,}000{,}000}{f^2 N^3}$$

* * *

(a) Will you kindly inform me whether it is absolutely necessary to waterjacket the heating or combustion chamber of any gasoline engine for any other reason than to keep the valves so that they do not stick, and to avoid premature ignition? (b) Is it not more economical and efficient to keep the combustion chamber at as high a temperature as possible if the sticking of the valves and premature ignition is avoided? The writer has noticed that on the majority of air-cooled engines which have been built recently in France that, while the cylinder along the piston travel is cooled by flanges or fins, the combustion chamber is waterjacketed. There must be some good reason for this, for I have noticed that on the latest types of French tricycles they have evidently found it necessary to waterjacket the combustion chamber as they are now doing.

(a) There is another reason for waterjacketing the compression space that is quite as important as those referred to. When the air and gasoline is drawn into the cylinder when its temperature is high,

it immediately expands, and this expansion reduces the amount of the charge. It is important to get as much fresh mixture as possible into the cylinder, for if the charge is in any way reduced, the power of the engine is decreased in proportion. This is the principal reason why an engine will frequently give considerably more power when cool than when it is hot. (b) If it were not for the difficulties which arise from an overheated cylinder it would be more economical to operate at a high temperature. Too high a temperature of the cylinder would prevent dissociation, and a proportion of the gases would not be consumed until they had passed from the exhaust port.

[This inquiry and answer appeared in 1901. Of course since that time there have been changes in the practice of cooling automobile engines; but even yet the contest between water-cooled, air-cooled and combined water and air-cooled engines is not settled.—Ed.]

* * *

(a) In the Gas-Engine Handbook is given a formula for finding the diameter of the crank-shaft. I presume that this formula applies to single-cylinder engines. What formula should be used for finding the diameter of the crank-shaft for an engine with two opposed cylinders, working on the same crank-pin? The cyl-

inders are supposed to give alternate impulses. Would there be any difference in the formula if there were four opposed cylinders working alternately, two cylinders working on one crankpin?

(a) The crank-shaft should be designed to withstand the total strain which is thrown upon it at any moment. Hence, when the cylinders are working in sequence, the same size shaft will answer for either one, two or four cylinders.

* * *

How should the brake horsepower of a gas engine be calculated when using a prony brake?

First measure the radial distance from the center of the crank-shaft to the point the brakearm bears upon the scale. Then the horsepower is found from the following formula:

B. H. P.=.0001904 pln.

Wherein p=the pressure in pounds upon the scales (net).

l=the length of the brakearm, see above.

n=the r. p. m.

For further information, see the chapter on testing, in the Gas-Engine Handbook.

* * *

Referring to the Handbook, I should like to know (a) upon what assumption the piston clearance of 30 per cent is

based. (b) Is the engine better with more or less clearance, and why?

(a) The clearance of 30 per cent of the piston displacement is 30 per cent of the volume, found by multiplying the area of the piston by the length of the stroke. (b) The higher the compression the greater is the economy of the engine. Danger of pre-ignition limits the compression to about 80 to 90 lbs. (gauge) on a gasoline engine.

* * *

Will you please tell me the general principles of vaporizers for using kerosene and the heavier products of petroleum in connection with an internal combustion engine? I do not care for details, but simply the main features, as an aid in designing.

The principal features of the later designs of vaporizing attachments, or, in fact, any of those used in connection with ordinary gas engines, are either atomizing the fuel by means of a fine spray with the assistance of heat to transform it into volatile matter or carbureting a portion of the air by first raising its temperature and passing it through or over a large body of the fuel. The vaporizer is preferred to the carbureter, as more certain in its action, and it is not so sensitive to atmospheric changes. Raising the temperature of the fuel is one of the essentials

in handling the heavier petroleum, and it is accomplished by passing it through an annular space surrounding the chimney of a hot tube burner, or through a space in the cylinder jacket, which is cut off from the water space. A departure from these methods is employed in the Diesel motor, in which a charge of pure air is compressed to a very high pressure and temperature, and the fuel does not enter the cylinder until the end of the compression stroke, when, owing to the heat of the compressed air, it takes fire as it enters.

* * *

In a two-cycle engine, how is it that the charge going into the cylinder from the crank-case is not exploded by the exhaust that is leaving the cylinder, the temperature of which is, according to some writers on gas engines, from 1,200 to 1,500 deg. F., yet a proper mixture of air and gasoline will ignite at 500 deg.? As far as I can learn, the pressure in the crank-case is from 8 to 10 lbs. per square inch. The terminal pressure of the exploded charge is much higher than that, so what is there to prevent the exhausted gases from entering the crank-case and firing the charge there?

The exhaust port in a two-cycle engine opens just sufficiently in advance of the inlet port for the pressure to reach very

nearly that of the atmosphere by the time the gases commence to enter the crank-case. If the engine is not properly proportioned, the trouble you anticipate will be in evidence. Again, if the charge is fired too late in the cylinder it will be of a sufficient temperature when the inlet gases enter to ignite them. Also, when the mixture is poor in gasoline, and hence very slow burning, crank-case explosions will occur. The success of a two-cycle engine depends on the nice proportion of the parts, and that is why so many amateur designers make a mess of the two-cycle engine.

* * *

(a) If a gas engine received an impulse twice in each revolution of the crank-shaft, would the efficiency of the engine be increased? (b) Would not such a construction be termed one-cycle?

(a) The efficiency of the engine would be increased in such a case, provided it were accomplished without an additional cylinder or piston. The friction load of an engine is practically the same for the same mechanism at the same speed; hence, if the number of impulses were to be increased, the mechanical efficiency would be higher. (b) No; because it is impossible to produce the complete series of operations on one side of the piston at every stroke. You apparently assume that a four-cycle

engine that is double acting would be classed as a two-cycle. A two-cycle engine is one which receives an impulse on one side of the piston for each revolution of the crank-shaft.

* * *

Would it be practical to build a rotary gas engine without a reciprocating piston? Has a practical rotary gas engine ever been constructed?

We have never seen a practical rotary gas engine, although about seven or eight schemes have been patented in this and in foreign countries.

* * *

Will you please give a simple formula for computing the area of a throttle tube about the nozzle for a constant vaporizer for use with two-cycle engine?

Make the area at the nozzle about one-third the area of the inlet and use an auxiliary air passage for high speeds.

* * *

Please give a formula for the volume and the area of the outlet for a muffler for automobile work.

The volume of the muffler should be from six to eight times the piston displacement, depending upon the room upon the machine. It will be found that the larger the muffler volume the quieter the exhaust. The exhaust passes out through a number of very small holes,

the combined area of which should be about equal to that of the exhaust pipe. For small engines ⅛-inch holes will be found about the right size.

* * *

What is the best practice in boring gas engine cylinders so as to provide for the expansion? If the cylinders are bored taper, what is the proportion of the taper to the diameter and stroke; that is, how much larger than the piston should the bore be at the beginning of the taper, and at what point of the stroke should the taper end?

Gas engine pistons are usually turned or ground smaller than the cylinder bore by 1-100 inch for each 1 inch of the diameter of the bore. Thus the outside diameter of the piston for a 4-inch bore would be 3.96 inch or 4-100 smaller. The writer does not know of any firm boring the cylinder taper; however, the general practice is to relieve the junk rings that divide the piston rings, making them slightly smaller than the balance of the piston. For instance, for a 4-inch bore the junk rings should be turned to 3 63-64 inches.

* * *

It is stated in the report of the "International Automobile Congress" that it is best to pipe the jacket, so that the coldest water is at the explosion end of the

cylinder and around the valve. If this is correct, why is it not practiced more in this country? In other words, has this theory been borne out in practice since the report was made?

We believe that the International Automobile Congress is right so far as theory goes, but in automobile practice there is so little difference in the temperature between the inlet and the outlet water that we can not see how it would very much matter.

* * *

Is it safe to advise compression under 80 lbs. when, under certain conditions, ignition will take place at that figure?

We have never found in practice that 80 lbs. was too much for a high-speed engine. As a matter of fact, 90 lbs. and even as high as 100 lbs. has been employed with perfect satisfaction.

* * *

Is it better to use a separate exhaust pipe and muffler with a four-cylinder engine, or just as well to use two separate pipes and one big muffler, or to run two big pipes into a large pipe close to the engine and one large pipe close to the muffler? If two separate ones are used, would it be better to have the two-cycle cylinders and their cranks together at the exhaust into one pipe than with the

cranks that are opposite, as usually arranged?

Personally we should prefer two separate exhaust pipes and two mufflers, making the mufflers as long as the space in the boat would allow. The principle of the muffler on the multiple cylinder engine is to have the exhausts emptying into one muffler as widely divided as possible; therefore the two-cylinders with cranks together should exhaust into the same muffler.

* * *

Do you use the same formula when choosing dimensions of a crank-shaft with two or more throws that you use in figuring one throw? Should the web on the two crank-cases with three throws be thicker than one with a single throw?

For a four-cycle engine the same sizes hold to and including four cylinders; for a two-cycle engine, up to and including two cylinders. If your engine is of the four-cycle type, the webs should be made the same as for a single-cylinder engine, but of the two-cycle type should be about 40 per cent stronger.

* * *

(a) Why are not two-cycle engines built in larger sizes for stationary purposes? (b) Are they not as reliable and economical as the four-cycle type? (c) Will they hold the horsepower if run

continuously the same as a four-cycle engine?

(a) You are probably not familiar with the latest practice in gas engines. One of the largest engines in the world today is one run by the Lackawanna Steel Works, in Buffalo, and is a two-cycle of 2,000 H.P. (b) If properly designed, they show better economy than the four-cycle type. (c) Yes, if properly designed and constructed.

* * *

(a) What is the thermodynamic efficiency of a gallon of 75 deg. commercial gasoline? (b) What is the theoretical and the practical thermodynamic efficiency of a gasoline engine? I want the mathematical analysis of both complete from start to finish. (c) What is the standard weight of one gallon of 74 deg. commercial gasoline, as would be used for purposes of calculation?

(a) The heat value of gasoline is 1,800 to 2,000 B. T. U. per pound. (b) The thermodynamic efficiency of a gas engine runs from 25 to 50 per cent according to the design. (c) The weight of one gallon of 74 deg. gasoline at 60 deg. F., is 5.71 lbs.

* * *

I have a copy of E. W. Roberts' "Gas Engine Handbook." On page 252 (fourth edition), it reads: "Gasoline mixtures

will not permit of a higher pressure than 85 lbs. per square inch at the ordinary piston speeds." Does this mean 85 lbs. absolute or above atmospheric pressure?

The pressure referred to is that above the atmosphere.

* * *

(a) Can a 4½-inch bore by a 6-inch stroke, four-cycle engine be successfully cooled by air if a fan is used? (b) Is there any other way to air cool besides a fan?

(a) Yes. (b) A blower may be used, but the fan is simpler.

* * *

(a) Is a two-cycle fit for stationary, under 8 H.P., 10 hours' run per day? (b) Can it be run as cheap as a four-cycle?

(a) We presume the inquiry refers to the closed crank-case, two-cycle type. It can be run successfully at long intervals without any trouble, so long as it is properly designed. (b) The question of fuel economy in a two-cycle engine is a point on which authorities disagree. It is generally considered, however, that it requires more fuel for the same power.

* * *

Why is it that a mechanically operated inlet valve requires ¼ lift in comparison with valve diameter, and a suction inlet ⅛ lift in comparison with valve diameter?

In order to get the area of the opening the same as the area of the opening under the valve it is necessary to give a ¼ lift with the mechanically operated inlet valve. Usually the suction valve is made much larger and the lift smaller so as to get an equivalent area. Compared to the mechanical valve, the suction valve cuts down the power to some extent.

* * *

(a) What is the best method of cooling a gas engine (double-acting) in which an explosion occurs every time the piston rod reaches either end of the cylinder? (b) Will a water-jacket (ordinary type) be sufficient? (c) Would the introduction of air inside the cylinder (for cooling purposes) interfere to any extent with the work of expansion and compression? (d) Can you mention any other methods of cooling?

(a-b) A double-acting gas engine must be cooled by both a water-jacket around the cylinder and water inside the piston rod and the piston. (c) This method is used to a certain extent for clearing the cylinder of burned gas. The amount of air necessary to have any appreciable effect in cooling would probably be more than you can get into the cylinder between the impulses. (d) Cooling by means of flanges or pins or the use of an

air-jacket with an exhaust fan, is used sometimes in place of water.

* * *

What is the relative efficiency of the two and four-cylinder gasoline engine?

That is a matter depending entirely upon the build of the engine. Some two-cycles give as good, and even better, economy than a four-cycle, but with the usual type of enclosed crankcase two-cycle, the consumption is from 10 to 20 per cent more than the four-cycle.

* * *

If it were possible to have as much compression on the crank case of a two-cycle engine as in the top of the piston, thereby having greater suction, would it give the engine greater power, and how much?

There is no advantage in securing a higher compression than will fill the cylinder with a fresh mixture and drive out all the burnt gases. The usual limit of the Day type of engine is between 8 and 10 pounds.

* * *

I see so much in books and magazines about the proper proportioning of inlet and exhaust parts of internal combustion engines. Can either be too large to be of benefit to the easy and economic working of engine, if the parts be properly placed, constructed and trimmed? Would it be harmful, if the whole end of the cylinder

were at once opened at the proper time, provided it were properly closed in time?

There is no good reason for excessive size in the engine valves. It is particularly harmful to have excessive size for exhaust valves, and it makes a great deal of strain on the valve motion. Nothing is gained by the use of over 100 feet per second in the inlet passage and 85 feet per second in the exhaust passages.

* * *

(a) What is the pressure most suitable to use in a compression-cycle engine using a low-grade oil heavier than kerosene? (b) What method is used in timing the engine with hot bulb?

(a) 75 to 80 per square inch. In other words, as heavy a compression as can be used without premature ignition. (c) Customarily timing with the hot tube or hot bulb is regulated by the length of the bulb and the distance of the incandescent portion from the mouth of the bulb where it opens into the cylinder. The longer ignition tube with the incandescent portion near the cylinder gives early ignition. A short tube gives late ignition. The time of ignition will be when the new mixture has sufficient compression to drive the dead gas in the tube back of the hot spot.

* * *

(a) When the explosion occurs in a gas engine and on the whole expansion stroke,

does the pressure force the cylinder rings ahead of it, or does the piston pull the rings? (b) If rings fit good and cylinder is true, would engine leak much if piston would be worn much? (c) How many square inches radiating surface to the H. P. are required with fan?

(a) The rings are usually drawn by the piston when the engine is new. If much worn the rings may push slightly. (b) It is best to have a good fit on the piston, but with rings that fit well there will be little leaking, even with a loose piston. (c) 1,000 square inches per H. P. for radiator of the coil type; 500 square inches per H. P. for a radiator of the honeycomb type. For an air-cooled engine it is customary to supply fins, of a length equal to about 1-3 the cylinder diameter and as many as practicable.

* * *

Please give me the rule for figuring out the sizes of cylinders for gas engines and oblige.

Let D=diameter cylinder in inches.
Let L=stroke in inches.
Let R=r.p.m.
Let N=number of cylinders.

Then $\frac{D^2 \times L \times R \times N}{15{,}000}$ =H. P. of four cycle engines.

$$\text{Then} \quad \frac{D^2 \times L \times R \times N}{12{,}500} = \text{H. P. of two cycle}$$

engines.

These denominators are for gasoline. For natural gas use 14,000 for two cycles and 17,500 for four cycles.

* * *

Will you kindly tell me how to figure the compression in the gas engine?

The compression pressure is found according to the following equation:

$$PV^{1.3} = 14.7$$

Wherein P the compression pressure (absolute), V the fraction of the maximum cylinder content which is comprised in the compression space.

The volume of the maximum cylinder content is the volume of the compression space plus the volume of the piston displacement. The quotient of the compression space divided by the maximum cylinder content gives the fraction to be substituted for V in the equation. As the problem is usually given, it is the quantity V and not the pressure that is desired. Suppose it is required to find the proportion of the compression space for a compression pressure of 100 lb. per sq. in. Substituting for P in the equation the desired pressure plus 14.7, to obtain the absolute pressure it becomes

$$V = \frac{\sqrt[1.3]{14.7}}{114.7}$$

As the extraction of the fractional root involves the use of logarithms, it is best to start with them.

1.167317 (Log. 14.7)
2.059563 (Log. 114.7)

$\bar{1}.107754$ (Log. quotient)

1.3) .892246

.686343

$\bar{1}.313657$ (Log. V=.2059

The first operation consists in subtracting the logarithm of 114.7 from the logarithm of 14.7, the difference being the logarithm of the quotient, which must be divided by the index of the root of 1.3 to get the logarithm of V. Before dividing by 1.3 it is necessary to subtract the logarithm from zero. The quotient obtained by dividing by 1.3 must then be subtracted from zero to get the logarithm of the result. The reasons for this are explained in works on logarithm. We can not spare the space to do more than illustrate the method. The reader should note that the result of the above solution is the ratio of the compression space to the sum of the piston displacement plus the compression space.

I should like to ask a few questions concerning the auxiliary exhaust for four-cycle engines. The writer has designed and built several two-cylinder four-cycle marine engines with cranks at 180°, the dimensions being 8¼ bore by 11 in. stroke. They are designed for 80 lb. compression, with a compression space of 230 cu. in., and rated at 34 H. P. at 275 to 300 r.p.m. The inlet valve opening is 2⅞ in., outside diameter of valve, 3 9-16 in., the exhaust valve opening is 3⅛ in. diameter, outside diameter of valve, 3⅞ in. The inlet is 2½ in. pipe and exhaust 3 in. pipe. These engines drive a propeller 38 in. in diameter in pitch. The first engine has been in operation about two months and we have noted that there is quite a severe strain on the mechanism for operating the exhaust valve, as it has shown considerable wear on the cam, which has 1¼ in. face. We have been considering the advisability of using an auxiliary exhaust, but are somewhat in doubt as to its efficiency, fearing that it will cause a draft of burnt gases from the muffler at the end of the suction stroke. (a) Would there be enough to be any harm? (b) Would there not be a difficulty in oiling this portion of the cylinder, as the port will be preferably on the back, where there is the greatest pressure from the pistons? We understand, of course, that an auxiliary port should be well water-jacketed. The

writer's idea would be to core the port in from the outside to within about 5/8 inch of the bore, and then to perforate the balance of the metal after the cylinder is bored. This would leave ribs between the holes for a guide for the piston rings. We should very much like to have your opinion on the matter.

(a) We do not think that there would be sufficient burned gas drawn in to be of consequence unless the port of the other cylinder was open at the same time, which is not the case with cranks at 180°. (b) The lubrication, if by the splash system, should attend to this portion of the cylinder. Otherwise it may be necessary to oil that side of the cylinder directly. We think that the best plan is to cut a port directly through without ribs, as these are likely to become overheated. If the port is not over 4 inches long, and the openings of the rings are kept away from it, there will be no danger of their jumping in. We suggest a port 1 in. by 4 in. This will be found to relieve the exhaust valve mechanism to a considerable extent, and will allow the size of the exhaust valve to be reduced somewhat.

* * *

Will you kindly advise me whether manufacturers of four-cycle engines have found it practical to use a subexhaust or port at the end of the piston stroke, similar to the

common two-cycle method? On several engines I have built, that is, two-cylinder four-cycle engines, 4 by 4½, I have had cast in the cylinder a port about ⅜ inch wide by 3 inches long, but it did not help the working of the engine as I had expected from similar experience with an air-cooled 1 H. P. motor. I am told that there are on the American market two or three engines which have a subexhaust to relieve the exhaust valve as it is about to open. I am anxious to know if they are successful.

The auxiliary or overrunning exhaust port is finding favor among gas engine designers everywhere for the reason that it relieves the valve-operating mechanism from a great deal of the strain that would otherwise occur, and decreases the liability of noisy operation. We should advise increasing the width of the exhaust port in your engine to ½ inch. It is the opinion of some gas engine men that the best results may be derived from this method when the exhaust from the auxiliary and the valve-controlled port escape to the atmosphere through separate openings.

* * *

(a) What is the usual compression employed in the gas and gasoline engines, and what difference should there be in the compression between an engine built for gas and one for gasoline to obtain the best results. (b) How high is it safe to go in

the matter of compression, and what is the highest compression you know of that has been successfully used? (c) Should not the compression be reduced in designing larger sizes of engines?

(a) The "usual compression employed" varies with different engines. For gas engines the most commonly used is from 60 to 90 pounds, although some engines use 110 to 120 pounds gage pressure; with gasoline engines the more common pressures are from 50 to 70 pounds gage pressure, although 80 and 90 pounds have been used. (b) With high compression we get premature ignition and the relative safety of using high compression depends upon the strength of the parts of the engine and their durability under such reversed stresses. With a compression of 80 pounds gage pressure with stove gasoline and of 110 pounds with some natural or artificial gases, ignition may be by the compression, and with constant load it is possible to run the engine without any other form of ignition, provided the jacket water outlet temperature is sufficiently high. Premature ignition may be recognized on the card by rounded corners at the heel even when there is no thump or other knocking of the parts due to the reversal of stress. Increase either in temperature or in pressure makes the gases more easily ignited and more combustible. Hence if the temperature of the jacket water at the outlet is reduced the charges

of gas and air which previously had been fired by "hot blast" or by cylinder ignition will no longer be ignited on account of the chilling of the walls of the cylinder by an excessive use of water jacket. Conversely, gases which obtain large percentages of nitrogen and carbon dioxide and which are difficult to ignite at low temperatures and pressures are more easily ignited when highly compressed. Compression may be increased if the heating resulting therefrom can be rapidly dissipated, as, for example, by the injection of water, the use of excessive quantities of air or large areas of cooled cylinder walls in the clearance or combustion space per unit of volume. (c) On account of the difficulty in adequately cooling the piston of large engines, the piston not unfrequently acts to ignite the charge. With water-cooled pistons this action is prevented. From recent experimental data received, we are of the opinion that it is not practical to carry as much compression in very large engines or engines running at high piston speeds, even when both the walls and pistons are thoroughly water-jacketed, as can be done with smaller and slower-running engines, on account of the inability to rapidly conduct and absorb the heat generated in the gas and air during compression. However, a trial of an actual engine will quickly decide it.

(a) Will you kindly inform me how to figure the compression and the compression space of a two-cycle engine? I am making a drawing of a two-cycle engine, 3-inch bore, 4-inch stroke, inlet port 5-16 inch in direction of piston travel; exhaust port 5-16 lead, or 5/8 from end of stroke. Cylinder and head cast solid, with water-jacket. I would like high compression, but do not understand how to calculate it. (b) Would one-half sphere be right?

(a) The rules for calculating the compression pressure of a gas engine are given on page 27, as well as The Gas Engine Handbook. When using these rules, assume that the pressure at the beginning of the stroke is that of the atmosphere, the same as is in a four-cycle engine. (b) Half a sphere for the end of the cylinder gives very good results in a four-cycle engine, and we have known a two-cycle engine to run very nicely with a spherical cylinder head. We have also known a two-cycle engine that was said to run with a compression pressure of as high as 91 pounds to the square inch. We believe, however, that 85 pounds per square inch is about as high as the compression pressure should be carried for a gasoline engine, unless it should be run at a very high speed.

* * *

Will you kindly give me information on the following questions? (a) Are there

compound gas engines, i. e., engines deriving additional power by further expansion of the exhaust gases in the low-pressure cylinder? (b) Do you believe that, with a powerfully constructed engine of this kind, additional power could be obtained? (c) Suppose a charge of gas and air were compressed in a perfectly tight receptacle to a pressure of 50 pounds to a square inch; what would be the pressure at the instant of ignition, and would the pressure afterwards fall to 50 pounds to the square inch?

(a) Compound gas engines have been built, and in operation have shown a greater economy than a single-cylinder engine. They have, however, proven troublesome, principally owing to explosions taking place in the low-pressure cylinder after misfires in the high-pressure cylinder. (b) We believe, however, that after they have been given a more thorough study, it will be found possible to produce an efficient compound gas engine. (c) If the charge were to be fired immediately after compression the pressure would rise to between 150 to 200 pounds per square inch immediately after ignition, or at the moment when the flame had been fully propagated through the mixture. We have no record of such an experiment, but believe that the pressure would return to 50 pounds per square inch as soon as the gases cooled sufficiently.

(a) What is the initial and the final temperature of a well built, four-cycle engine? (b) Why are not the cylinders made longer in order to get all the expansion possible?

(a) The initial temperature depends upon the fuel and the compression previous to ignition. It ranges somewhere in the neighborhood of 2,800° Fahr. The final temperature is between 300 and 500° Fahr. (b) Lengthening the cylinder will not increase the expansion as has been assumed by the inquirer.

MECHANICAL DESIGN.

I find by experiment that gasoline ignites with a sharper report than does natural gas. The above experience prompts me to ask, what is the best proportion of the compression chamber when gasoline is to be used? For instance, what should be the length of the compression space in a gasoline engine with a stroke of 14 inches?

It is not usual to make any difference in the proportion of the compression space when designing gas and gasoline engines. The proportion most commonly used is 30 per cent of the stroke or the piston displacement. For a 14-inch stroke this would give 4.2 inches as the length of the compression space, provided it was kept the same diameter as the remainder of the cylinder.

* * *

What is the best and simplest form for a gasoline engine muffler? I have seen several, and can not decide on which would be best. My engine is a 10 H. P.

A good form of muffler is a simple expansion chamber, and it should, for best results, be 4½ times the volume of the piston displacement. Make the muffler in two pieces, each one of which should be in the shape of an old-fashioned bell-crown hat. Bolt the rims together and put in

your pipe. Be sure that the entry is not opposite the exit.

* * *

Please explain a good form of starter that I can make without much expense and trouble.

A good form of starter is a tank of compressed air and a good plug-valve. Turn the engine over until it is just past the inner center on the outward stroke, and open the valve until the stroke is about half completed. Catch it again on the next working stroke and then turn on the fuel.

* * *

Can two charges of explosive mixture be exploded simultaneously by jump-sparks with one battery and coil, or will two of each be necessary ?

Yes, it may be done by placing the ignition plugs in series and using a coil of double the usual capacity. Thus, if the coil for one spark is just sufficient to give a good one at the plug and the maximum sparking distance is one-half inch, it will probably be necessary to use a coil with a maximum sparking distance of one inch for two plugs. We would suggest that you experiment upon this point. Lighting gas jets in series is quite an old arrangement.

* * *

What should be the compression of a two-cycle engine, 4½ by 4½ inches, and

how much variation may there be in the compression without affecting the running of the engine?

Make the clearance from 30 to 40 per cent of the piston displacement. Any appreciable variation in the compression will affect the power of the engine.

* * *

(a) What will be the effect if the exhaust is too large and located too near the compression space, other than a slight loss of power? (b) Would the engine refuse to run on this account?

(a) None. (b) No.

* * *

I have a design for a gas engine in which the cylinder is 6 inches diameter and the stroke 7 inches, the speed being 400 r. p. m. I propose to use a flywheel 25 inches diameter, with a rim 5 inches deep and 5 inches across. Will this flywheel be heavy enough for a stationary engine?

Assuming that your engine will develop 7 I. H. P., and that two flywheels of the dimensions given will be employed, the coefficient of unsteadiness will be .066. As a coefficient of .05 is usually that employed on stationary engines for the ordinary run of work, the flywheel is too light. This flywheel could be improved by increasing the diameter to 35 inches. The rim should then be 4 inches deep by 3¼ inches wide.

(a) Is a flywheel 17 inches diameter and 42 lbs. in weight suitable for an automobile engine 3⅜ inches diameter by 4 inches stroke? (b) If this is right, what weight of flywheel would be proper for a two, a three or a four-cylinder engine?

(a) In order to answer this question intelligently it is necessary to assume the speed of the engine and the center of gravity of the flywheel rim. Taking the former as 600 r.p.m. and the latter as 13 inches, and taking the mean effective pressure in the engine to be 75 lbs., the I. H. P. would be 2 H. P., and the proper weight of the flywheel, according to the formula just given, would be a little over 18 lbs. If the engine is to be run at much lower rates of speed for any length of time, it would be necessary to compute the flywheel for the lower speed, but it is probable that a 25-lb. flywheel 17 inches diameter will be found amply heavy for the engine under all conditions. (b) In multiplying the cylinders and so arranging the impulses that they occur at equally divided intervals, the flywheel may be theoretically divided by the number of cylinders. Assuming, however, that one or more cylinders may be out of commission owing to accident or other causes, the flywheel should be so designed that it will be sufficient for the smallest number of cylinders that are likely to be in use at one time.

Is it feasible to build a gas engine which employs both ends of the cylinder: i. e., a double-acting engine?

Yes, such engines are in use, and are quite successful for large power units. They employ a water-jacketed piston-rod packing to prevent the rod from getting overheated.

* * *

Please publish the dimensions of a ½ H. P., four-cycle, high-speed gas engine, giving diameter of cylinder, stroke of piston, diameter of valves, diameter and weight of flywheel, revolutions per minute of crankshaft.

As the fuel upon which this engine is to operate and the purpose for which it is intended are not given, it will be assumed that the engine is to be run with gasoline. The speed of the engine should be 500 r. p. m.; the diameter of the cylinder, 2½ inches; the stroke, 3¾ inches; diameter of the valves, each ⅞ inch; diameter of flywheel for a marine engine, 12 inches, for a stationary engine, 16 to 18 inches; weight of flywheel for a marine engine, one of 50 lbs., for a stationary engine, two of 75 lbs. each.

* * *

What is the proper size for the exhaust for a 3½ H. P., two-cycle gasoline engine?

Use 1¼-inch pipe.

What is the best size of tube for the ignition of a 1½ H. P., stationary, four-cycle engine?

It is best to employ the same size of tube on all engines. For wrought-iron tube the size is ¼ inch. The best tube is that made of a special alloy called nickel steel.

* * *

(a) What will be the horsepower of a gasoline engine with a piston 6 inches diameter and 6 inches stroke? (b) How close to the cylinder head should the piston be when at the compression end of the stroke? (c) What is the rule for calculating the latter? I would like to have you assume such dimensions of the engine as I have not given, and that are necessary for the solution of the above questions.

(a) Assuming that the engine is of the four-cycle type, and that its speed is 250 r. p. m., the horsepower that would be delivered at the pulley would, under the best conditions, be 3 H. P. (b) This distance depends entirely upon the shape of the compression space in the cylinder. If the valves open directly into the cylinder, this distance should be about two inches. (c) The general rule is to make the volume of the compression space from one-half to one-fourth that of the piston displacement.

* * *

(a) What should be the diameter and stroke of a 50 H. P. gas engine to run at

150 r. p. m.? (b) What should be the diameter and weight of a flywheel for this engine when used for ordinary work?

(a) 16x24. (b) 3,100 lbs. should be the weight of the rim of each flywheel, and the outside diameter of each wheel should be 10 feet.

* * *

(a) Will you kindly inform me whether the jump spark has been used with success with stationary gas engines? (b) If so, does it require a different battery or induction coil than is employed with the make-and-break? (c) What is the comparative cost of maintenance? (d) What material is employed for the electrodes? (e) How often do they have to be cleaned to keep the carbon from bridging across?

(a) Yes. (b) A jump spark requires an induction coil with two windings, usually known as a Ruhmkorff coil. About the same amount of battery power is required as with the make-and-break. (c) The cost is dependent upon the method of making the spark. With a single break in the primary circuit, the cost is less with the jump-spark. (d) An alloy of platinum and iridium. (e) Usually once a day.

* * *

(a) In designing a gasoline engine, what is the proper compression of the mixture in pounds per square inch? (b) What per-

centage of the cubic contents of the cylinder should be given to the clearance space?

(a) Much depends upon how carefully the engine is designed and constructed. In order to obtain the best possible economy, and especially if the engine is a large one, we should advise a compression of about 85 lbs. per square inch. (b) For the pressure just given make the clearance 23 per cent of the total cylinder volume, or 30 per cent of the piston displacement.

* * *

I should like to have you show a cut of a good valve for timing a tube igniter, one that would give good results and not be likely to get out of order.

We believe that the best form for such a valve would be a small poppet as is employed for the exhaust valve of a four-cycle engine. It should be made with a cast-iron head, or else entirely out of nickel steel.

* * *

Will you kindly inform me what should be the depth and the width of a flywheel rim for a gas engine, single cylinder, running at 400 r. p. m., hit-or-miss governor? The flywheels should be not over 30 inches diameter, and two wheels are to be used.

As the correspondent does not give the class of work that this engine is designed for, it will be assumed that it is for average duties, with a coefficient of unsteadiness

equal to .03. The I. H. P. will be assumed as 8 H. P., and the limit of missing to be one miss to one explosion, or an explosion every fourth revolution. With a rim 4 inches deep, the flywheels should weigh 692 lbs. each, and the width of the rims should then be 7½ inches. For pumping, this weight should be multiplied by .6, giving 415 lbs. as the weight of each rim, and 4½ inches as the width. For electric lighting, multiply by 1.33, giving 920 lbs. as the weight of each wheel, and 10 inches as the width. In the latter case, it would be advisable to decrease the width of the wheel by increasing the depth.

* * *

(a) I have a new engine with a bore of 3¼ inches and a stroke of 4 inches. The compression space is 6½ cubic inches, and I should like to ask what the compression pressure should be, provided there were no leaks? (b) It is a four-cycle engine, and I am getting about 4-7 B. H. P., with the engine running at 400 r. p. m. Do you think this is as much as the engine should give? (c) I depend upon sucking the gasoline from a small tube at each cycle. Would you consider it better to use a mixing valve a short distance from the inlet valve proper? In other words, would the mixture be more complete if taken from about two inches from the inlet valve?

(d) The inlet port is now 5/8 diameter. Should it be larger?

(a) With this compression space and no extraordinary leakage, the compression pressure would be about 140 lbs. per square inch. This shows that the compression space is too small. It should be not over 11 cubic inches. (b) The engine is doing fairly well for the speed at which it is run. (c) As no sketch of the device in use has been submitted, we can not give an intelligent answer to this question. It is probable that the tube is the best device if properly arranged. (d) We should advise making the inlet 3/4 inch diameter.

* * *

Will you kindly give me the benefit of your opinion on the following: I desire to take the water outlet from the top of the cylinder head in a two-cycle engine and to put on a tee close to the head, so that I can shunt a part of the water into the exhaust pipe. The water will enter the exhaust pipe quite near to the exhaust port of the engine, and there will be only a close nipple and an elbow between the point of entrance of the water pipe and the exhaust port. Will there be any danger of the water being drawn into the cylinder, or of its backing in?

We do not believe that the water would be likely to enter the cylinder, with the arrangement you have described.

I have a gasoline automobile engine that does not give sufficient power, and propose to add another cylinder, opposed to the present one, with both connecting rods operating upon one crankpin, one connecting rod being forked at the crankpin so that it will straddle the other. Would you consider this plan a feasible one?

We believe the plan to be perfectly practicable, and, in fact, it is in use to a certain extent.

* * *

(a) What should be the areas of the exhaust and the intake for a 3x3-inch, four-cycle engine, running at from 1,000 to 1,500 r. p. m., the intake pipe having two fine wire screens. (b) What should be the weight of the flywheels?

(a) Area of inlet and the exhaust the same for this small engine, and at least ½ square inch or 13-16 inch diameter. (b) The flywheel for an automobile engine is somewhat of an experiment to determine, as it depends more upon how slowly the engine is to be run than anything else. We suggest that you try a 40-lb. flywheel, with a rim 10 inches diameter. If your engine does not run steadily enough at slow speeds, it will be necessary to increase the weight, but we believe that the weight given will be sufficient. This weight is for one flywheel when but one is used.

I have a two-cycle gasoline engine which I wish to convert from hot tube to electric ignition, as the tube will not start off with any certainty. I notice that most builders use the hammer-break instead of the wipe-break igniter. Is this owing to patents which prohibit its use, or because of the superiority of the hammer-break type?

There is no patent that covers every form of wipe-break igniter. We believe that the hammer-break is that most universally used, although several manufacturers appear to prefer the other form.

* * *

In a two-cycle engine what would be the effect of raising the compression in the crank-case to about twenty pounds per square inch?

The effect would probably be to reduce the efficiency of the engine, except for extremely high speeds. Ten pounds is the highest pressure we have known to be used successfully, higher pressures necessitating the choking of the by-pass and power is wasted in driving the gas through it.

* * *

Will it be safe to run an engine with 3¼-inch bore at high speed, if the wall of the cylinder is only from ¼-inch to 9-32-inch thick? This is for a water-cooled engine. (b) Would there be any

danger of bursting the cylinder if back firing should occur?

(a) A ¼-inch wall is perfectly safe for a 3¼-inch cylinder. (b) No.

* * *

Will you kindly tell me how to make a suitable muffler for a four-cycle engine, 3x3, running about 1,800 r. p. m.?

A formula for muffler design is given on page 177 of the Handbook. For a 3x3 engine this formula will give 94½ cubic inches as the volume of a suitable muffler. As this muffler is evidently for an automobile engine, it should be made of sheet iron about 3½ inches in diameter and 10 inches long. Mufflers should be strong enough to withstand a pressure of 100 lbs. per square inch. Two concentric cylinders will be found sufficient for an engine of this size, and they should be perforated with about ⅛-inch holes, the combined area of all the holes being equal to 1½ times the area of the exhaust pipe.

* * *

I am making two drawings for and am going to build a two-cycle gasoline engine of the enclosed crank-chamber type. The size will be 3½x3½ inches. I am making the inlet and the exhaust ports the same size, ⅜x3¾ inches, and am somewhat at a loss to determine their exact position. I decided to place the ports

in such a location that the exhaust port would be entirely uncovered when the inlet begins to open, and to have the inlet port entirely uncovered just as the piston gets to the dead center. Would you kindly give your opinion as to the size of the ports and their position and about what speed could the engine run?

Perkins' table in the "Gas Engine Handbook" gives 3/8x3¼ inches for the size of the inlet port and 7-16x3¼ inches as the size of the exhaust port. The drop, or the distance the exhaust port should be opened when the inlet begins to open, is given as ⅛ inch. The speed of the engine is given as 500 r.p.m. for a marine engine.

* * *

(a) What should be the size of the inlet and the exhaust ports for a 5x6 inch engine running at 1,000 r. p. m.? (b) Do you recommend jump-spark ignition for such an engine? (c) Would you recommend a float-feed vaporizer or carbureter ? (d) Do you consider the speed chosen too high for this engine? (e) What horsepower should the engine develop at the above speed?

(a) Make them both 2¼ inches in diameter. (b and c) Yes. (d) Not if the engine is well balanced. However, 750 r. p. m. would be in better accord with later practice for the normal speed. (e)

At 1,000 r. p. m., 8 H. P. At 750 r. p. m., 6 H. P.

* * *

(a) What is the best practice in locking connecting-rod cap screws, especially on two-cycle engines? (b) What is the best method of locking the piston pins? I have been using cap screws on connecting-rod cap, setting into the cap and locking with a nut, and have also used a sheet-steel lock under the head of the screw. Which do you consider best? In regard to piston pins, I have always used a set-screw recessed into the pin and locked with nut, but have had them loosen and give trouble.

(a) Either of the methods of locking cap screw have proved very effective in practice. That used in the Elmore carriage is probably the easiest and simplest to apply, and we do not know of a failure of this type to lock. (b) The set screw and lock nut for the piston pin is usually considered a very effective method, and if carefully tightened up should not work loose. Another plan is to use a screw dowel in the end of the piston pin, the dowel being half in the pin and half in the piston.

* * *

(a) What would be the correct sizes of inlet and exhaust ports for a 3½x3½ inch two-cycle engine? (b) What should

be the size of the compression chamber, that is, the length of the chamber, etc.?

(a) Make the width of the inlet port in the direction of the piston travel 7-16 inch and the width of the exhaust port in the direction of the piston travel 11-16 inch. Make the length of the inlet port 1½ inches and the length of the exhaust port 1⅝ inches. (b) Make the length of the compression space 1⅛ inches.

* * *

(a) In a four-cycle gasoline engine, 5-inch bore and 6-inch stroke, what would be the speed to develop respectively 4 and 5 H. P. at the brake? The engine is to be provided with an auxiliary exhaust. (b) In such an engine what would be the size of the inlet and exhaust valves when an auxiliary port is used? (c) What would be the size when the auxiliary port is not used?

(a) Four horsepower, 475 r.p.m.; 5 H. P., 600 r.p.m. (b) Make the inlet valve 1¼ inches in diameter and the exhaust valve 1 inch in diameter. (c) Make both valves 1¼ inches in diameter.

* * *

(a) In an engine having a 5-inch stroke what should be the pressure and temperature at the end of the stroke? (b) What temperature should be obtained by compressed air to explode a

mixture containing kerosene and heavier oils?

(a) The pressure and temperature will depend entirely upon the clearance space at the end of the stroke. Without knowing this it will be impossible to answer the question. (b) It is evident that the question as it is refers to the pressure. This as used in the Deisel engines is 550 pounds per square inch to give a temperature sufficient to burn kerosene and heavier oils. This temperature, however, gives the combustion temperature and not the ignition temperature of the fuel, which is probably what is wanted.

* * *

(a) What should be the size of the opening at the spraying nozzle for a two-cylinder, two-cycle engine, 4-inch bore, 4-inch stroke and having a 1¼-inch pipe for the inlet? We find that the generator type of valve gives an erratic mixture, varying with the speed and the head of the gasoline. (b) Do you advise an auxiliary air inlet for the higher speeds with a float feed and a generator valve?

(a) The size of the throttle tube should be about ⅝ to ¾-inch. (b) We would advise the use of an auxiliary inlet for the higher speeds.

* * *

What is the best method of locating the cylinder oiler in the vertical four-

cycle marine engine in order to insure the lubrication of the piston pin?

The most efficient manner of oiling the piston pin of any vertical type is by the splash system with the enclosed crankcase. The cylinder oiler should be placed so it is opposite the lower piston ring when the piston is at the bottom end of the stroke. A groove should extend along the cylinder wall, so it is slightly uncovered by the piston, when it is at the top of the stroke. Two or more grooves of about ⅛-inch deep should be on the lower end of the piston.

* * *

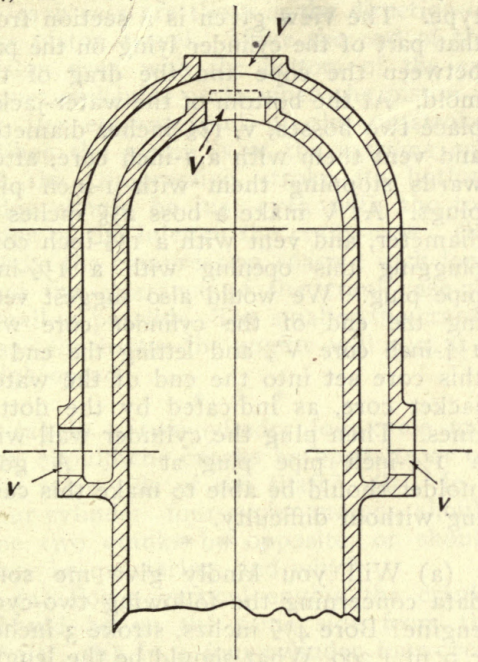
(a) What would you think of making a double-cylinder, four-cycle engine, 4-inch bore and 4-inch stroke, with only the cylinder walls water-jacketed and with the inlet valve in the center of the head? (b) What power should this engine develop at 800 r. p. m.?

(a) We believe it is best to always water-jacket the cylinder head, although we have known engines to work successfully without it, provided the compression was not too high. It is just about as easy to make the cylinder head water-jacketed and it makes the engine so much better. Placing the inlet valve in the center of the head is just about as good as any other construction, although sometimes found rather inconvenient. (b)

You can probably get about 6 B. H. P. at the rated speed.

* * *

I have designed and constructed the patterns for a two-cycle gasoline engine, 4x4½ inches, and would like to have



your suggestions regarding the venting of the water-jacket core so that I may be able to get good castings. I am making

the cylinder head and jacket integral with the main parts of the cylinder, and have designed it for a spherical head.

In the accompanying illustration is shown a method which we have found very successful for a cylinder of this type. The view given is a section from that part of the cylinder lying on the part between the cope and the drag of the mold. At the bottom of the water-jacket place two bosses, v, 1⅞ inches diameter, and vent them with a 1-inch core, afterwards stopping them with 1-inch pipe plugs. At V make a boss 2⅛ inches in diameter, and vent with a 1½-inch core, plugging this opening with a 1½-inch pipe plug. We would also suggest venting the end of the cylinder core with 1¼-inch core V^1, and letting the end of this core set into the end of the water-jacket core, as indicated by the dotted lines. Then plug the cylinder wall with a 1¼-inch pipe plug at V^1. A good molder should be able to make this casting without difficulty.

* * *

(a) Will you kindly give me some data concerning the following two-cycle engine? Bore 4½ inches, stroke 3 inches, r. p. m. 1,200. What should be the length, width and location of the three ports? (Crank-case inlet to be uncovered by the piston. No check valve to be used.) (b)

What are the proper volumes of the clearance space and the crank-case?

(a) The exhaust port 9-16 inches; inlet port 5-16 inches; both 2¼ inches wide; inlet in crank-case 21-32 inch by 2 inches. Note that the smaller dimensions in each case are those in the direction of the piston travel. Make the end of the piston even with the bottom of the exhaust and inlet ports when the piston is at the extreme end of the outstroke. When the piston is at the extreme end of the compression stroke its bottom edge should be just even with the top edge of the inlet to the crank-case. (b) Make the compression space 1 inch long and the clearance of the crank-case as small as possible. The smaller the crank-case the better the engine will run at a high speed.

* * *

(a) In a two-cylinder four-cycle motor, should the cranks be opposite or on the same side of the shaft? (b) In a four-cylinder four-cycle motor, should the two cranks be opposite, or should they be quartering, and why?

(a) For a vertical engine the cranks should be on the same side from the shaft. (b) In a four-cylinder four-cycle engine we should place the two center cranks together and the two outside cranks at 180 degrees with these. The

reason for this is that it gives a better balance and divides the impulses up, making a steadier running motor and using less flywheel.

* * *

(a) What will a 3½x5-inch four-cylinder motor develop at 600 r. p. m.? (b) What should be the dimensions of the valves and the bearings?

(a) About 9½ H. P. (b) We should make both valves about 1⅛ inches diameter. This is a little large for the speed, but we believe it will allow you to run your engine at higher speed with ease, if you can do so — though 1-inch would probably answer for this speed—without cutting down the power appreciably. The crank-shaft of this engine, if steel, should be 1¼ inches in diameter, the outer bearing 2½ inches long, and the inner bearings 2 inches long if there is room. The crank-pin should be 1¼ inches or 1⅜ inches diameter, and at least 1¼ inches long. The piston pin should be ⅞ inch diameter, with a bearing the same length as the crank-pin.

* * *

Will you kindly give me some data for a four-cycle engine of 8-inch bore by 10-inch stroke and 500 r. p. m.? (a) What should be the size of the inlet and the exhaust valves? (b) What should be the size and the weight of the flywheels?

(c) What horsepower should be obtained? (d) If the bore should be increased to 10 inches and the engine run at 600 r. p. m., how much would it increase the power, and what should be the sizes of the valves and flywheels?

(a) Inlet valve, 3 inches diameter; exhaust valves, 3¼ inches. (b) Flywheel 48 inches diameter, with a total weight of rim equal to 300 pounds for such ordinary duties as pumping. (c) The horsepower at 500 r. p. m. should be about 20. (d) Increasing the bore to 10 inches and the speed to 600 r. p. m. would increase the power of the engine to 38 H. P. This would call for a 4⅛-inch inlet and 4 7-16-inch exhaust, but owing to the increase of speed it will be found that the same size and weight of flywheel will give practically the same results.

* * *

Is there any gain in holding the inlet valve open one-fourth stroke after the piston has started back on the compression stroke for a four-cycle engine, such as used in automobile work? I find in repairing automobile engines of a well-known make that the valves are set in this way.

It is quite right to leave the inlet valve open during a portion of the compression stroke, but we believe that for a very

high speed the valve should close earlier than one-fourth of the stroke.

* * *

What per cent compression space is allowable on two-cycle engines? Would 1½ inches be too much on a 4½x4½-inch?

Thirty per cent, or about 1⅜ inches for a 4½-inch stroke.

* * *

Why is a two-cycle not made with a small bore and long stroke like the four-cycle? I should think with it the fuel consumption would be lower.

The reason for so many two-cycle engines having a larger bore than stroke is, in the first place, that more of them are used for marine engines, and a short stroke makes a short engine; second, the large bore and short stroke makes it easier to get a light compression in the crank-case. We believe that within certain limits the two-cycle engine would work better with a longer stroke than bore.

* * *

(a) What should be the proper size for inlet and the exhaust pipes to use with a four-cylinder, four-cycle engine 8¼x9 inches, running at 500 r. p. m.? (b) What should be the diameter and the lift of the valves, both of them mechanically operated, and the most lift it would be advisable to use?

(a) Use 3-inch inlet pipes and 3½-inch exhaust pipes. (b) Use a 3-inch inlet valve and a 3½-inch exhaust valve. Give the inlet valve a lift of ¾ inch and the exhaust valve a lift of ⅞ inch. This is all that is necessary to use, and more would be wasting the power of the valve operating mechanically.

* * *

(a) We are building a 3x4-inch gas engine, and wish to know how much compression it should give if the compression space is 25 per cent of the piston displacement. (b) Will this give us a mean effective measure of 75 pounds at 450 r. p. m.? (c) Will a 50-pound flywheel, 16 inches in diameter, be heavy enough?

(a-b) If the engine is designed properly you ought to get a mean effective pressure of at least 90 pounds. (c) You do not say for what purpose the engine is to be used, but if for an automobile or marine purpose we should think it would be quite heavy enough.

* * *

What are the relative advantages in an upright two-cycle engine of splitting the crank-case horizontally, as compared with the use of sideplates?

We believe that with careful workmanship each is just as good as the other.

I am building a two-cylinder, two-cycle engine, with the inlet in the cylinder wall just under the exhaust, and covered and uncovered by the piston. Diameter of cylinder is 5 inches, with 4½ inches stroke, compression 1¼ inches, with deflector and follower nut taken out, ought to give me a compression of about 80 pounds. What I mean by the follower nut you may not understand. The rings will be made in the usual way, but will not be jumped over. I am making a loose junk ring and follower, same as in the steam engine. I find that the rings are considerably distorted by the act of springing them over a solid piston. The cylinder walls and head are water-jacketed. The ports are large, inlet port about 1½ square inches, exhaust port about 2 square inches, will turn from 700 800 r. p. m., vaporizer of the float-feed type. I would like to make the inlet and exhaust in one casting, which of necessity will become very hot from the exhaust. Will the heat have any effect on the gasoline vapor, which, of course, will strike the hot pipe before entering the crank-chambers? If so, I could make them with separate pipes, but would prefer making it the other way, as I think I could use coal oil instead of gasoline after pipe was once heated up.

It would be all right, we think, to

make these in one casting if kerosene were to be used; however, it is preferable to let the air into the engine as cold as it will work successfully, and perhaps it would pay you in the end to make the openings separate.

* * *

(a) What horsepower will an engine develop with a 3-inch bore by 5-inch stroke at 450 r. p. m.? (b) What would be the best speed for an engine of this size to run?

(a) About 1¼ H. P. (b) We believe that this engine would run better at 600 r. p. m., provided the valves are large enough.

* * *

(a) What horsepower would I obtain from a four-cycle engine, 4½-inch bore and 6-inch stroke at 400 r. p. m.? (b) What would be the ideal compression when the engine was running at 300 r. p. m.? (c) At 400 r. p. m.? (d) What would be the size of the intake and exhaust valve?

(a) Three H. P. for a single-cylinder engine. (b-c) We do not understand what is meant by "ideal" compression. It is customary with engines of this size to make the space one-third of the piston displacement. (d) At 400 r. p. m. the inlet valve should be 15-16 inch diameter, exhaust valve 1 1-16 inches.

What size would you recommend for the inlet and exhaust valves? What should be the weights of the flywheel and what should be the maximum horsepower on gasoline for the following engines: 5½x8-inch, 350 r. p. m.; 10¼x14-inch; 12x18-inch at 180 r.p.m.?

Our correspondent has given us neither the diameter of the flywheel nor the purpose for which they are intended to be used, and in order to answer this part of the inquiry it will require us to do considerable guess work. The revolutions per minute in the second size engine have not been given and are estimated at 225. For a 5½x8-inch engine we would recommend an inlet ⅝ inch diameter and an exhaust 1⅞ inches diameter. The engine should give on gasoline a maximum B. H. P. of 5.2. For a 10¼x14-inch engine we suggest 3¼-inch inlet and a 3⅝-inch exhaust, and the B. H. P. should be 20. For the 12x18-inch we would suggest a 4-inch inlet and a 4½-inch exhaust and the B. H. P. should be 28.

* * *

How much compression should there be in a well-constructed 5x5-inch cylinder, two-cycle gasoline motor?

Eighty pounds per square inch.

* * *

I am building a two-cycle, two-cylinder 4x4 gas engine to run at about 700

r. p.m. What should be the diameter, length and number per square inch of threaded studs that would give ample cooling surface by the use of a fan at the top?

Use 3-16-inch studs about 1¾ inches long, spaced ⅜-inch centers, and place them as far down in the cylinder as the top of the piston is when at the bottom of the stroke.

* * *

Will you kindly answer the following questions regarding a valveless three-cylinder, two-cycle engine, 4⅜ inches bore by 4½ inches stroke, which will run at 200 to 1,200 r.p. m.?

(a) Size and weight of flywheel. (b) Diameter and length of shaft bearings. (c) Diameter and length of crank-pins. (d) Size of crank-case inlet. (e) Size of cylinder inlet. (f) Size of cylinder exhaust. (g) Number of carbureters and type. (h) Number of mufflers. (i) Number of radiating surfaces required.

(a) Eighteen inches diameter, 150 pounds in rim. (b) Crank-shaft bearings, 1⅝ inches diameter, 3½ inches long. (c) Crank-pins, 1¾ inches diametre by 1⅝ inches long. (d) Crank-case inlet, 1 inch in direction of piston travel by 2 inches, giving 2 square inches. (e) Cylinder inlet, 9-16 inch by 2¼ inches. (f) The cylinder exhaust, ⅞x2¼ inches.

(g) One vaporizer will answer, provided the cranks are set at 120 deg., as they should be. The vaporizer should be of the compensating type. (h) Either one muffler or three should be used. One muffler, if made of large volume, will do very nicely, as the exhaust is sufficiently divided. We would suggest a muffler about 6 inches in diameter, and, if possible, 4 feet long. (i) We are not able to give you any information upon radiating surfaces required, as we have no data on air-cooled, two-cycle engines, nor do we know of any one who has tried them as large as this.

* * *

(a) What should be the compression space in an engine 4x5 inches? (b) What compression should this engine show on a pressure gauge? (c) What diameter should the inlet valve and the exhaust valve be?

(a) Four inches diameter and 1½ inches long. (b) About 85 pounds. (c) Inlet diameter, 1¼ inches; exhaust diameter, 1⅜ inches.

* * *

(a) In a two-cycle motor, ports extending nearly all the way around the cylinder, say separated by about ⅜ inch for baffle plate between, can the ports be made narrower in the piston's travel than if using shorter ports? (b) What

is considered the most practical style of baffle plate?

(a) The port should open at a certain point in the piston travel, depending on the speed, independent of the width around the cylinder. (b) There is quite a difference of opinion about baffle plates, some using a straight face, others a semi-circle, convex to the center of the piston, and others a semi-circle, concave to the center of the piston. Good practice gives a baffle plate with an outer face one-fourth of the diameter from the center of the piston and straight across.

* * *

What is the highest crank-case compression in a two-cycle engine that is most practical for efficiency?

The crank-case compression should be between 4 and 8 pounds, 10 pounds being the practical limit.

* * *

In examining a six-cylinder motor I note crank-shaft bearings are cast iron with no bush whatever. Do you consider steel working on cast iron good for bearings?

We have seen such bearings used, but it is not considered good practice.

* * *

(a) What is the highest cylinder compression in a high-speed two-cycle that is thus far in practice? (b) Could, say

100 pounds, or at least over 85 pounds compression be used if there was 80 pounds at point of ignition? What I mean is would it not promote efficiency if the electric ignition preceded the pre-ignition due to compression at over 80 pounds?

(a) Eighty-five pounds. (b) The greatest compression that may be used without getting too early an ignition is the most efficient. So long as the ignition does not precede the proper ignition point of the electric igniter no harm will be done.

* * *

In an eight-cylinder, two-cycle are the cranks and order of firing set in rotation from or beginning with cylinders No. 1 to 8?

Put the crank-pins of adjacent cylinders at 180 deg. and the two adjoining cylinders with their cranks at 90 deg. to this. The impulses will then be 1, 3, 2, 4. It will not matter so much about the other four cylinders, so long as they are arranged as above for the four cylinders.

* * *

Why is the long-stroke engine not adapted for automobiles?

Long-stroke engines must be run at lower speeds and usually take more room for their power.

(a) How much power will be developed by a 5½x5½-inch two-cycle at 800 r. p. m.? (b) What should be the sizes of the ports and compression space for the above speed. (c) What size propeller would be suitable for this engine?

(a) Between 40 and 45 H. P. Exhaust port 1x2⅜-inch. Inlet port from crankcase 11-16x2⅜-inch. (b) Compression space 1⅝ inches long. (c) The propeller depends not only upon the power of the engine, but the size and lines of the boat, and the matter should be taken up with the manufacturers of propellers, giving them all the data possible regarding these points.

* * *

Will you kindly state the best proportions for the inlet and exhaust valves of a 5x8 engine to run to 1,000 maximum when it is desired to have as little lift as possible? It is a question which I do not find settled in any of the textbooks, and my tests are in accord with only one. The weight of exhaust places a limit on diameter.

The ordinary rule for an engine of this size and speed calls for an inlet valve 3½ inches diameter, and an exhaust valve 3⅜ inches diameter. The lift should be ¼ of the diameter to get the opening. An engine of this size and speed should have mechanical valves, and if it is desired to

make the valves smaller, multiple valves should be used.

* * *

(a) What length around the cylinder wall, what width and how much drop should the ports of a 3-inch bore, 3½-inch stroke, two-cycle gasoline engine have, running 500 r. p. m. (b) What length should the compression space be, and what area should the port have, connecting the crank-case and the cylinder? (c) Also for a 2½x2½-inch two-cycle cylinder, running 1,200 r. p. m.?

(a) Make both inlet and exhaust ports 1½ inches at right angles to the stroke. Make both ports fully open when the piston is at the bottom of the stroke. Make the exhaust port open 9-16 inch and the inlet port open 7-16 inch before the end of the stroke. Make the transfer port 1½x½ inch. (b) Make the compression space 1 inch long, transfer port 1½x⅜ inch. (c) Make the exhaust port 7-16x¼inch, and the inlet port 5-16x 1¼ inches. Make the transfer port 1¼x ¼ inch, and the length of the compression space ¾ inch.

* * *

We wish to convert a set of our marine engines into stationary engines. We have thought of using a throttling governor between the carbureter and the engine base. Can you advise us how best to do this?

Attach your governor to a double-ported valve in the by-pass. Any good governor will answer.

* * *

I would like to ask you the following questions regarding the six-cylinder, two-cycle engine, 6¼-inch bore and 4-inch stroke: Will these dimensions give satisfactory results and also are the following proportions correct? Compression space 1¼-inch long, cylinder wall ⅝-inch, water jacket wall ⅜-inch thick, water space 1-inch, inlet 2½-inch diameter, 4½-inch square area. Transfer port 4-inch square, piston 6¼-inch by 7-inch long, connecting rod 9-inch, center to center. Piston pin 2-inch diameter, 2-inch long, crank-shaft 2½-inch diameter, crank pin 3-inch diameter. What horsepower should the engine give at 900 r. p. m. and 1,200 r. p. m.?

According to modern two-cycle practice, a larger bore than stroke does not give such a good working engine. We would not advise making the bore any larger than the stroke, and much better proportions are to make the stroke from 1.2 to 1¼ times the bore. You will get practically the same power as with the 5⅛-inch by 6-inch. For the 6¼-inch by 4-inch we should advise cylinder wall 9-16-inch, water jacket wall 5-16-inch thick, water space ¾-inch, inlet 2-inch diameter; 2-inch inlet will be ample for 900 r. p. m. and about 2¼-inch exhaust.

This will give 3⅛-inch area for the inlet and 4-inch area for the exhaust. The transfer port should be 2⅛-inch square. We should consider the piston rather short, although it may be impractical to make it longer on account of clearing the crank-shaft. Probably a 9-inch crank-shaft will be necessary to give clearance for the end of the piston. This can only be told by laying out the engine. We should make the piston pin about ½-inch diameter by 2½-inch long. The crank-shaft may be gradually increased in diameter toward the after end. Starting at 1⅜-inch for the three forward bearings, 1¾-inch for the next two, and 2-inch for the last two, or, in order to keep uniformity, they may be made 2-inch throughout. We recommend the crank pin being made 1⅝-inch for the two forward cylinders, 1¾-inch for the next two, and 2-inch for the last two cylinders, or 2-inch throughout. The dimensions given on your sketch are unnecessarily large. In order to insure cool running it will be necessary to make your crank pin 3½-inch long. This may seem excessive, but it is necessary on account of the excessively large diameter of the cylinder. We recommend the outer bearing being 5-inch long and the inner bearing 3-inch long. The compression space of 1¼-inch will answer very well, but 1 3-16-inch would be better for the compression space.

(a) What size should the port openings be in a 3½-inch by 3½-inch bore and stroke, two-cycle engine, running 1,000 revolutions, using a suction inlet into crank-case through a poppet valve—that is, if you think if a poppet valve will work at that speed? (b) Could I keep this engine cool by using copper pins to radiate the heat? If so, what size and how many pins should be used?

(a) It is rather difficult to make an engine with a check valve operate successfully at 1,000 r. p. m. Use a piston-opened port, and make the ports as follows: Exhaust 19-32-inch by 2-inch, inlet 7-16-inch by 2-inch; crank-case port 11-16-inch by 1 7-16-inch. The smaller dimensions are those in the direction of the piston travel. The inlet and the exhaust ports should have their bottom sides even with the top of the piston when the piston is at the top of its stroke. The crank-case inlet should have the top side even with the bottom of the piston when the piston is at the top of its stroke. (b) We believe that an engine of this size could be kept cool by copper pins. We would suggest using 3-16-inch or ¼-inch pins, 1 inch long, and as close together as they can be placed and covering the cylinder wall from the bottom of the cylinder ports to the top and also covering the cylinder head.

Why is it that the jump spark is not more generally used on stationary gas engines? Theoretically, would it be any more economical, provided one used a liquid battery, say Edison type RR.?

For ordinary work in stationary practice, and particularly with a hit-and-miss engine, the jump spark is quite satisfactory; but in the throttling engines, and especially those that use a weak mixture, a special coil is required for the jump spark. However, we have known of a very successful petroleum engine of the throttling type that has been using the jump spark method of ignition for years. The jump spark is the most economical.

* * *

(a) Which is considered the best practice in constructing gas engines of from 10 to 50 H. P., the overhanging cylinder or the one bolted to the bed through flanges on the sides of the cylinders? (b) Which is the cheapest to produce?

(a) The overhanging cylinder, supported on a pedestal, when very long, to allow for expansion. (b) The overhanging cylinder is much the cheaper to produce.

* * *

I have a two-cycle engine, 3¾-inch bore by 3½-inch stroke. The space between the piston and the cylinder head when the piston is at the top of the stroke is 1 3-16-inch. Is this right?

We believe better results could be obtained by increasing the compression space to 1 inch.

* * *

In a two-cylinder gas engine, how should the cranks be located for best results?

In a four-cycle engine the cranks should be both on the same side of the crank-shaft. In the two-cycle engine at 180 deg.

* * *

(a) I am designing a two-cylinder vertical gas engine to develop 100 H. P., what should be the bore, stroke, revolutions, diameter of crank-shaft, length of main bearings, and weight and diameter of flywheel? (b) In case a third cylinder were added, making engine 150 H. P., what then should diameter of crank-shaft be, and what changes should be made in flywheel? (c) What changes in these details are necessary when engine is used on producer gas? (d) What advantage in an engine of this size has a small bore and long stroke over an equal bore and stroke?

(a) We should recommend 14½-inch by 18-inch at 235 r. p. m., crank-shaft 5¼-inch diameter, main bearings 10½-inch long, diameter of flywheel 72-inch, weight of rim 1,775 lbs. for electric light work. (b) The same diameter of crank-shaft holds in this case. The flywheel may be one-third lighter. (c) This bore and stroke will give about three-fourths as much on producer

gas as on natural gas or gasoline. As the flywheel is proportioned to the indicated horsepower, this could be made smaller in proportion, also on account of the smaller initial and mean effective pressure the crank-shaft and bearings need not be so large. Theoretically, the best efficiency is given when the stroke is 1½ times the bore.

* * *

In calculating the weight for the rim of the flywheel suitable for a 6 H. P. gasoline automobile engine, I am having considerable trouble in getting a rational answer. Will you kindly show me how it is figured? The data I use is as follows: Horsepower, 6; diameter at center of gravity of rim, 12.75; speed, 1,200 r. p. m.; coefficient of unsteadiness, .335. Using the formula No. 22, page 163, of the "Handbook," the result obtained is 7 lbs., which is obviously wrong. Will you kindly show me where I have made a mistake and the proper way of calculating this?

The discrepancy in your results is due to, first, using what is evidently the B. H. P. of the engine for the I. H. P., and the maximum speed of the engine instead of its lowest speed. In absence of cylinder dimensions, we will assume the mechanical efficiency of the engine to be 75 per cent. Then the I. H. P.—8. Then take the lowest speed at which the engine should run, giving its full impulse. This will be when climbing

grades on high gear, with the throttle wide open, and, assuming it to be 300 r. p. m., the formula becomes, substituting this figure, and ¼ the I. H. P., as the engine runs at ¼ speed:

$$\frac{2 \times 111{,}600{,}000{,}000}{(12.75)^2 \times (300)^3 \times .335} = 152 \text{ lbs.}$$

If there are to be two wheels, make each with 76-lb. rims.

* * *

Would you please give me the size of ports for two-cycle motor 2½-inch bore, 3-inch stroke to extend 2½-inch at right-angle to piston running at 1,200 r. p. m., or more?

Inlet port ⅜-inch by 1½-inch; exhaust port ½ inch by 1½ inch; inlet port to crank-case 9-16-inch by 1¼-inch. We do not believe anything could be gained by extending the port any further around the cylinder as you suggest.

* * *

Which is preferable for high-speed motors with touch-spark ignition, an igniter mechanically operated or operated by piston?

The hammer break igniter, operated from the outside, is much the more satis-

factory, but jump-spark ignition will probably give you more satisfactory results.

* * *

Please give the size of ports in a two-cycle 5x5-inch. Also the compression space necessary to get the best results. Is it possible to run a two-cycle engine 1,200 r. p. m. without a skip or miss?

For a high-speed engine the inlet and exhaust port should each be 2⅝-inch around the cylinder and the exhaust port should measure 15-16-inch in the direction of the stroke and the inlet port ⅝-inch. The bottom of the port should be even with the top of the piston when the latter is at the bottom of its stroke. The compression should be about 85 lbs. per square inch, and the compression space 29 per cent of the piston displacement. If the engine is made of the three-port type, with compensating vaporizer, it may be run at even a higher speed than 1,200 r. p. m.

* * *

Would you kindly state if 1-inch piping is large enough for a 4-inch by 5-inch gas engine running 600 revolutions, and would it do at 900 revolutions? The valves have a 1⅜-inch opening. I refer to the intake pipe above. The exhaust has a 1¼-inch pipe.

A 1-inch inlet and a 1¼-inch exhaust piping are large enough for 600 r. p. m.,

but for 900 r. p. m. both pipes should be 1½-inch.

* * *

I have an engine that requires a spark coil with three wires. The coil is worn out. I have a spark coil with two poles, and wish to know how I can wire for the two-pole coil.

The two-pole coil is evidently a primary spark and will not answer for jump-spark ignition. Your best plan is to secure a new jump-spark coil.

* * *

What power will be developed by a 4¾-inch by 6-inch engine at 450 r. p. m.?

From 3½ to 4 H. P. for a four-cycle

* * *

I have designed a cylinder, making it air-cooled, using 16 flanges 3-32-inch by 5-32-inch by 1¼-inch. According to some engineers, the width of the flange should not exceed 10 or 15 times the thickness, and I have used the average thickness and made the width equal to 10 times it. (a) Do you think I can keep the cylinder cool at 800 r. p. m. by the use of these flanges and a blower, delivering air at the exhaust and also on edge of each flange and at top? (b) I have used a spherical construction of piston, and would like to have your opinion of it. It is certain that it would take a ball of gas ignited in center less time to be completely ignited than a layer of gas ignited

on one side, and I have endeavored to use this principle by dishing the piston head. What weight flywheel should be used for a three-cylinder engine of these dimensions, 4.5-inch by 4-inch, to be 14-inch diameter? Would a 50-lb. rim be sufficient? (c) I have used a rather large exhaust, 3-inch by ¾-inch, using a formula for exhaust calling for about 2 by 13-16-inch. I have two transfer ports opening into the cylinder amounting to 3-inch by ½-inch, endeavoring in this way to reduce the tendency of the live gas to mix with the burnt gas. (d) The inlet to the crank-case is 3-inch by ⅝-inch. Would a large carbureter, having two mixing valves, be large enough to use for this engine, or should three smaller ones be used? (e) Will there be any advantage in using an automatic timer, the speed of the engine controlling the position of the contact and governing by throttle alone? (f) What horsepower should I get from a three-cylinder engine composed of cylinders like one in sketch? I have figured on 15 to 20 H. P.

(a) There is no reason why you should not keep the engine cool if you have sufficient air current, although we believe it would have to be a pretty large blower to answer for such a large bore. (b) We are in doubt whether a spherical construction of the head will answer for a two-cycle engine, although it is certainly the best for

a four-cycle. The position of the spark plug will probably give you trouble with sooting. We would suggest at least a 100-lb. flywheel. (c) For a piston speed of 800 feet per minute, which is usual in an automobile engine, your exhaust is none too large. The proportions you refer to are for a 4-inch bore, and even this would be a little small. The size of your transfer port is also about right. (d) We should increase the size of the inlet port in the crank-case, making the three openings 1-inch by 11-16-inch. Your vaporizer need not be any larger than would be necessary for one cylinder, provided the cranks are set at 120. We would suggest a vaporizer with compensating shutter rather than a mixing valve. (e) We believe that an automatically governed timer is a very good thing; however, it should be subject to hand control as well. (f) 24 H. P. at 1,200 r. p. m. In general, we should say that very much better results would be obtained by using 4-inch bore by 4½-inch stroke, or similar proportions if higher power is desired. An engine of that size should give you 20 H. P. at 1,200 r. p. m.

* * *

Would you consider a 1-inch pipe large enough for intake of a 4-inch by 5-inch engine, run at 600 r. p. m., if the admission valve is 1⅜-inch diameter?

No. A 1-inch pipe is too small in area for the intake.

* * *

Will you please give me a little information as regards ports. Which of the ports are correct, as shown in the enclosed sketch? Should the inlet open when the exhaust is open 5/8-inch, as shown in Fig. 1, or should the exhaust port open 15-16-inch before the inlet opens, as in Fig. 2? How long should these ports be for an engine to run 900 r. p. m., stroke of 4-inch, bore 4 5/8-inch? I expect this engine to run at 900 under load of 14-inch fluke wheel.

It is not worth while to publish the sketches, as we believe both to be radically wrong. The inlet port for this engine should be 1/2-inch in the direction of the piston stroke, and the exhaust port 3/4-inch in the direction of the piston stroke. Both ports should be 2 3/8-inch long, and no cross ribs are necessary. The bottom edge of both ports should be even with the top of the piston when the latter is at the bottom of its stroke.

In this case the drop will be 1/4-inch; that is the distance that the exhaust port is open before the inlet begins to open. If the inquirer will make a third port for the intake into the crank-case 7/8-inch by 1-inch, so that the piston closes the crank-case port when it has made 7/8-inch of its stroke, much better results will be obtained at high speeds.

(a) What position should the third port of a two-cycle gas engine be? Size, 3½x3½-inch, running 800 r. p. m.? (b) What length piston should be used?

(a) We should make the crank-case inlet ¾-inch by 1-inch, and so place it so that when the piston is at the top of its stroke the lower edge of the piston will be even with the top of the port. (b) Make the piston at least 4¼-inch long.

* * *

Will you kindly, in your answers to inquiries, give me the size of the port opening of a three-port, two-cycle, 3¼-inch by 3¼-inch engine, running at 1,200 r. p. m.? Will the ports require more than one bar across each to keep the rings from catching in the port edges? (b) I compute the compression space to be ¾-inch, as proportioned from the closing of the exhaust port as being the actual piston displacement. Is this correct? Will not a 95-lb. compression give more power? (c) I am building this engine with inside flywheels, 14-inch in diameter, 1¼-inch thick. Should it run successfully? (d) At what point in the stroke should the compression relief cock be placed to insure easy turning of the crank and yet preserve enough of the compression to secure the starting of the engine while the cock is open? (e) What should be the size of the hole? (f) What size vaporizer should I use on this engine? Will the same

size do for a 4½-inch by 4½-inch? (g) Should the water space be deeper for the thermosyphon cooling system than where a pump-circulating system is used?

(a) Inlet ⅜-inch by 1⅝-inch, exhaust 9-16 inch by ⅝-inch, crank-case inlet ⅝-inch by ⅞-inch. No bars will be necessary if the rings are so pinned that the openings will not come opposite the ports. (b) Compression space should be 15-16-inch. This will give you 85 lbs. compression. More than this will probably cause premature ignition. (c) We do not believe that the inside flywheel will work successfully in a two-cycle engine, as it will be difficult to get sufficient crank-case compression. (d) Place the compression relief cock at ½ stroke. (e) Make the inlet for a ⅛-inch pipe tap and use an ordinary relief cock. (f) About 1-inch diameter. A 1¼-inch would be necessary for the larger engine. (g) Not necessarily, but the circulating pipes should be about twice the size required for forced circulation.

* * *

(a) Of two engines having the same horsepower—one, a large-bore, low-compression, low-speed engine, the other a small-bore, high-compression, high-speed engine—in which will there be the greatest wear in the bottom of the cylinder? (b) I am building an engine, and, wishing to eliminate as much of the wear in the bot-

tom of the cylinder as possible, which is the best, a light piston or an exceptionally long rod? (c) What is the proper length for the rod in a four-cycle, 9-inch by 18-inch engine, with 90 lbs. compression and a speed of 260 r. p. m.?

(a) The wear is proportional to the speed and the pressure when the surface is the same. The pressure on the cylinder wall should generally be limited to about 20 lbs. per square inch of projected area. It should be noted that the pressure is not that on the cylinder head, but must be figured in graphically from the greatest angle of the connecting rod. Space will not permit a full treatment of this subject in these columns. It will be found in several works on gas engine design. (b) The weight of the pistons has very little to do with the wear, as it is but a small fraction of the pressure. Light pistons are necessary to high-speed engines. A rod 2½ to 3 times the stroke is the usual practice in stationary engines. (c) We should recommend a rod 45 inches long for these conditions.

* * *

(a) What would you consider the proper dimensions for a two-piston, two-cycle engine, 4-inch bore and 4-inch stroke, charged from a separate pump? (b) What should be the diameter of the crank-shaft and the diameter of the crank-pin? (c) What

should be the length of the compression space for this engine?

(a) Not knowing the speed of your engine, we would not know what area to give for the ports. For speeds between 600 and 1,000 we should make the width of the inlet port ½-inch, and the width of the exhaust port ¾-inch, both in the direction of piston travel. The length of the piston port will depend upon the speed of the engine. (b) Make the diameter of the crank-shaft according to the way it is connected up. For one piston 1¼-inch would be right for the crank-shaft and 1⅜-inch for the crank-pin. (c) The length of the compression space—that is, the distance between the two pistons when at the end of their stroke—should be 2⅜ inches. We suggest that you let the inlet port be uncovered by the other. You will then need no deflecting plate.

* * *

I am going to build a four-cycle engine, with two cylinders 2-inch bore by 6 inch stroke. (a) Would this engine have as much power as a single-cylinder engine of the same stroke, but with a bore of 4 inches? The engine is to drive a runabout, to seat two people. (b) What size clutch should be used? (c) What form of ignition should be employed? (d) What should be the weight of the flywheel? (e) Will 1¼-inch crank be large enough? (f) Should the cranks be opposite?

(a) No, not over one-half as much; 2 inches by 6 inches is a poor proportion. (b) For the 4x6-inch engine, single cylinder, about 10-inch diameter. (c) Jump spark. (d) About 20-inch diameter, 100 lbs. in rim. (e) No; use about 1⅜-inch diameter. (f) For a two-cycle engine, or an opposed four-cycle, yes. For a vertical four-cycle, the cranks should be together.

* * *

Am building a gas engine 3¾-inch bore by 4¾-inch stroke. (a) What power will this develop at 500 r. p. m.? (b) Are 1-inch inlet and 1¼-inch outlet large enough? (c) How much space for compression is required? (d) Should there be a regulating valve on the inlet?

A four-cycle engine is assumed. (a) 2 H. P. (b) Yes. (c) 15½ cubic inches. (d) There should be a throttle between the inlet and the vaporizer.

* * *

I have a four-cycle, 4½-inch by 5-inch horizontal engine, with a 220-lb. flywheel, 28 inches in diameter, and makes 630 r. p. m., with 2¼-inch compression space. It is run on city water gas. (a) What would be the horsepower of this engine? (b) Is the flywheel in proportion? (c) Is not the compression space too great? (d) How would ¾ of an inch go?

(a) 3½ to 4 H. P., if properly designed, with large compression, as at present, probably not over 2 H. P. (b) It is about right. (c) Yes, the compression space should be not over 23½ cubic inches. (d) This depends entirely upon the volume of the valve chamber. If the valves open directly into the compression space, it would be too small, and the space should, in this case, be 1 7-16-inch long.

* * *

I am building a vertical two-cylinder 4 x 4 engine. (a) Which way should the crank shaft be made? The crank pins opposite each other or on a straight line? (b) What horsepower will this engine have at 1,000 r.p.m.? (c) Are the following proportions right: 1 7-16-inch crank shaft, cylinder walls 7-16 inch thick, connecting rod 7½ inches long, compression space 1 inch?

(a) Opposite for two-cycles, in line for four-cycles. (b) 11 H. P. for two-cycle, 8 H. P. for four-cycle. (c) No, make shaft 1¼ inch diameter; walls, 5-16 to ⅜ inch, according to iron; connecting rod, 8 inches long; compression space, 1 3-16 inch for two-cycle.

* * *

Please give me the size of the admission port into the crank-case, also the size pipe connection to carbureter of a three-port

two-cycle engine, 5½ bore by 6 stroke. The cylinder inlet port to be 3¾ by ⅝, exhaust port 3¾ by ¾; the area of these ports is 2.34 and 2.81 square inches, respectively. They have been made large purposely for high speed—that is, 590 r.p.m., which is a speed of 5,000 feet per minute for the inlet, and 5,000 for the exhaust. I had in mind to make the crank-case admission port 1⅛ by 1¾, and use a 1½ pipe connection for the carbureter, the area of which is 2 square inches. The smaller dimensions of the ports above refer to the direction of piston travel.

We should prefer to make the ports as follows: Inlet 3½ by ¾, exhaust 3½ by 1⅛, crankcase inlet 1⅛ by 3, pipe to carbureter 2, exhaust pipe 2½. You may speed the engine to 750 r.p.m. if you wish.

* * *

What is the best way to make a muffler for two-cycle engine that will not give much back pressure on the engine?

Two or three concentric cylinders of Russia iron make a good muffler.

* * *

How much gasoline should a 5¼x7-inch four-cycle engine running at 300 revolutions use at each charge or any number of charges? (b) What B. H. P. should this engine give, supposing everything in good shape? (c) Can a magneto be used to operate a jump spark in connection with dry batteries for starting?

(a) .0004 pints per charge, 3.6 pints per hour; (b) 3.6 B. H. P. (c) Yes.

* * *

(a) Will 1-inch intake valve and 1¼-inch exhaust valve be large enough for a 4¼-inch bore by 6-inch stroke gas engine at 400 revolutions? (b) How long should the compression chamber be, as there are no side pockets? (c) What power should such an engine develop?

(a) Yes, ample. (b) 1¾ inches. (c) About 2¾ H. P. on gasoline and about 2½ B. H. P. on natural gas.

* * *

I would like to know if oil can be used as a cooling medium in the jacket of a four-cycle 10 H. P. engine instead of water, and, if so, what kind and what quantity. The capacity of the jacket is about twenty-one quarts. The reason I ask is that the water we uses destroys a tank very quickly and the tanks are quite expensive; also, our tank is 3x8 feet, and. owing to its size and location, is very much in the way. I thought that if oil would do, even if the first cost is a little more. it would be cheaper in the end, particularly if a smaller tank would answer. The engine has a 7½-inch piston, 7½-inch stroke and makes 300 r. p. m. on gas.

Oil has been used quite successfully for this purpose, the amount depending upon the facilities for cooling the oil. In auto-

mobiles we believe no increase in the size of the radiator is required. But the oil was used in winter only. The oil found best for this purpose is that known to the trade as "Ice machine" oil. Stationary oil-cooled engines usually employ a common steam radiator for cooling the oil.

* * *

Are two-cycle engines—say 4x4-inch cylinder—built to run at as low speed as from 300 to 400 revolutions; my understanding is that a two-cycle is a much higher speed engine than a four-cycle. (b) Can you advise what the proper speed would be for a two-cycle engine of the above cylinder size? (c) If a two-cycle engine will operate at the above mentioned speed, will the power be effective?

(a) Yes, from 250 r. p. m. to 1,600 r. p. m. There is no great difference in the speed range of the two types if properly designed. (b) For stationary work 600 to 750 r. p. m. For marine work up to 900 r. p. m. or 1,000 r. p. m., and for automobile work 1,2000 to 1,600 r. p. m. (c) Certainly.

* * *

Please give the following information in connection with a three-port two-cycle marine gasoline engine: Three-inch bore and 2½-inch stroke to run 1,000 to 1,200 revolutions. (b) Size of transfer space. (c) Size of exhaust pipe and vaporizer. (d)

Should the piston rings be wider than the ports in order to prevent cutting into same? (e) Give method of making core box for water space, spherical head. (f) Thickness of crank-case.

(a) Cylinder inlet 5-16x1½-inch, exhaust 7-16x1½-inch, crank-case inlet ¼x 1¼-inch, (b) ¼x1½-inch, (c) ¾-inch for each. (d) Not necessarily. They may be pinned so that the opening in the ring can not turn to come opposite the ports. We would suggest three rings ¼-inch wide. (e) We have not space to explain the method of making a jacket corebox. We advise the assistance of a first-class pattern maker. (f) 3-16-inch.

* * *

Referring to your "Gas Engine Handbook," I find no mention made of the relation of volume to pressure in mixture of gas and air calculated to give the highest efficiency in a gasoline engine. I should be greatly obliged were you to give me what information you may have upon the subject. (b) I also find that all calculations are based upon a certain relation of piston stroke to diameter of cylinder, for an engine designed to be used in a carriage it would, under certain conditions, be a great advantage were the stroke short and the diameter of the cylinder large. How far is it possible to carry this in an engine of about 6 H. P., 300 to 500 r. p. m.?

(a) The relation of volume of pressure is given on page 110 of the "Handbook." The compression pressure for highest efficiency is the highest that the fuel will allow, the limit being that pressure at which the mixture will ignite prematurely. This matter is discussed in the fourth and subsequent editions on pages 252 and 253. In engines with water-cooled pistons, the compression may be carried much higher, and even 160 pounds per square inch is said to have been obtained with such an engine on natural gas. (b) You are mistaken, as other formulas are given for any relation of the bore and stroke; 300 to 500 r. p. m. is low for the average automobile engine, the average piston speed of which is usually 800 feet per minute. We have seen some very successful automobile engines in which the bore was 1¼ times the stroke, and marines with a bore nearly 1½ times the stroke, as 8½-inch bore by 6-inch stroke.

* * *

Will you kindly answer the following questions in regard to a two-cylinder opposed 3x3-inch two-cycle engine of the three-port type? (a) What size should the ports to be run at 1,500 r.p.m.? (b) I intend using a separate cylinder instead of the crank-case to supply the working cylinders. Should I make the top edge of crank-case inlet come even with the

bottom of the piston when the latter is on the inner dead center? (c) What size crank-shaft and flywheel should I use? (d) Which would be the better balanced engine—one in which the explosions in both cylinders occurred at the same time; that is, a double impulse every other stroke—or one in which the explosions occurred alternately; that is, a single impulse every stroke? I think the former would be, but would require a little heavier flywheel to carry over the idle stroke. (e) If I use kerosene that is vaporized before entering the cylinder, how much compression should I use? (f) What per cent of the total cylinder volume or of the piston displacement should the compression space be when using kerosene for fuel? (g) when using gasoline? (h) about what power should I get on each?

(a) Exhaust ½x1½ inch, inlet ⅜x1½ inch, bottom edge of ports even with ends of piston when latter is at the inner center. Crank-case port, if used, 1½x1¼ inch. (b) We see no necessity of employing a separate cylinder for an air pump, as the crank-case performs this function very well. The edge of the inlet farthest from the crank-shaft should be even with the inner edge of the piston when the latter is at its outer dead center. Use only one inlet for crank-case. (c) Crank-shaft

1 3-16 inch diameter, flywheel 12 inch diameter, about 60 pounds. (d) Make the crank-pins 180 degrees apart, so both explosions come together. (e) We have found that the compression for gasoline works very well with kerosene. (f and g) 30 per cent. (h) About 6 H. P. on gasoline and 6½ H. P. on kerosene.

* * *

(a) Will you kindly give me the sizes of the inlet and exhaust valves of a four-cycle engine of 4-inch bore and 4½-inch stroke, to run 1,200 r. p. m.? What should be the height in inches of the compression space and what horsepower will this engine develop? (c) What is meant by the pitch of a propeller?

Inlet valve opening 1 9-16-inch diameter, exhaust valve opening 1 11-16-inch diameter. It is customary to make both valves the same size and we would suggest 1⅝-inch diameter for each valve. (b) With valves opening directly into cylinder and no valve box, 1 5-16-inch long. (c) The distance the screw would move in a fully resisting substance at each revolution. It is the same as the pitch of a thread on a bolt.

* * *

Please inform us of the meaning of a "three-port engine."

The "three-port" two-cycle engine is one in which the mixture enters the

crank-case through a port opened and closed by the piston. This gives it three ports. The usual type draws the mixture into the crank-case through a check valve and is called a "two-port" engine.

* * *

I am making drawings for a 1 H. P four-cycle engine. Will you kindly inform me how nearly I am right in the following specifications: Three and one-half-inch diameter, 5-inch stroke; piston 5¼ inches long; crank-shaft 1 3-16-inch diameter; crankpin 1¼-inch long, 1¼-inch diameter; piston pin ⅞-inch diameter, 1¼-inch long; exhaust valve 1 7-32-inch diameter, 5-16-inch lift; inlet valve 1 3-32-inch diameter; 9-32-inch lift; pipes both 1-inch; port from valve box to cylinder ⅝x1¾-inch; combustion chamber 2 inches of cylinder length; connecting rod 10 inches long, ⅞-inch mean diameter, 1¼-inch long; exhaust valve 1 7-32-1¾-inch face, rims 2 inches thick, weight of rims approximately 50 pounds each. r. p. m. 500; cam-shaft ¾-inch diameter? (b) I wish to make the water jacket core box of gas pipe, but find that 5-inch pipe is a little too large. Will it answer to line the pipe with heavy sheet iron?

(a) It is drawing things rather fine to go thirty-seconds of an inch in the diameters of the valves. We would make the inlet 1⅛-inch diameter and the ex-

haust 1⅛-inch diameter. Also use 1¼-inch pipe, as 1-inch is too small. (b) Sheet iron alone is good enough for the core-box.

* * *

(a) I am using a gasoline engine which feeds the gasoline directly into the cylinder by suction through the inlet valve. Would it use less fuel by only taking hot air from the exhaust pipe instead of cold air as usual? (b) Does the engine gain or lose power by using hot air?

(a) That engine uses the smallest amount of fuel which has the most thoroughly mixed charge. It is presumed that what you propose is to take the air from a jacket surrounding the exhaust pipe. This would probably make certain that the fuel was thoroughly vaporized and the best possible mixture obtained that could be produced without the use of a carbureter. The use of hot air to a certain extent is an advantage, but to use air too hot induces a tendency to premature ignition or back-firing. A good vaporizer does not require hot air except in freezing weather, and some forms do not need it even then, although they will work a little better when it is used. It is best to divide the air current, so that a portion or all of it may be passed through a heater and thus place the temperature under the control of the operator. To use

air from the exhaust pipe would make the engine inoperative, as the air would be denuded of its oxygen and be useless, (b) The engine will drop off in power directly in proportion to the increase in temperature, as the air is rarified by heating it and not so much will get into the cylinder as when it is cooler.

* * *

(a) Can the crank of a two-cycle gasoline engine be successfully lubricated by dipping in oil in a closed crank-case? (b) Would not the splash impregnate the vapor enough to lubricate the cylinder and would it not interfere with the electrodes of the firing device?

(a) Yes, this is the way in which they are nearly all of them lubricated. (b) The lubrication is accomplished by the oil striking that portion of the piston which overruns the cylinder into the crank-case. The secret of lubrication by this method is to have only about one-half inch of the end of the connecting rod dip in the oil. Overlubrication causes trouble by carbonizing the interior of the cylinder and is especially harmful when jump-spark igniters are used.

* * *

(a) Will a brass casting make a good gasoline engine cylinder? (b) Has gasoline any effect upon brass?

(a) Brass has been employed success-

fully for making gasoline engine cylinders. (b) None that we have heard of

* * *

(a) I would be pleased to have you explain in the columns of your journal how the crank-case lubrication works. I presume the rims of the flywheels run in oil and throw a spray against one side of the cylinder. It would seem to me that this would lubricate only one side of the cylinder wall. (b) Are there grooves in the cylinder to circulate the oil? (c) Will an engine 3¼-inch bore and 3¼-inch stroke be able to run faster than one of the same diameter, but having a stroke of 3¾ inches? (d) How does the oil reach the piston-pin with splash lubrication?

(a) Splash lubrication, as this system is generally called, is striking a small body of oil in the crank-case and the cylinder. That it carries the oil to every part of the case and against the walls of the cylinder has been proven by practical tests. (b) Grooves are usually turned in the piston near its open end. (c) All things considered, the shorter the stroke the higher the practical rotative speed. (d) See answer under (a).

* * *

I am building a double cylinder gas engine with the following dimensions: Two cylinders, 5-inch bore, 6-inch stroke, cranks set at 180 degrees; compression 77 lbs., exhaust valves 1¾ inches diameter, 11-32

inch lift; exhaust pipe 1½ inch; inlet valve 2 inches diameter, 3-16 inch lift; inlet pipe 1¼ inch; flywheel 17½ inch diameter, 125 lbs. in rim. What horsepower should it develop, running at 800 r.p.m., and the principal measurements consistent, and do they conform with the best practice?

An engine should develop, if properly designed, 12 to 14 B. H. P. at 800 r.p.m. The figures given are, all of them, too small for the best effect. The area of the exhaust passages should be 3.15 square inches, and of the inlet 2.56 square inches. It is therefore evident that the exhaust valves should be at least 2 inches in diameter, and should have at least ½ inch lift. The inlet valve should be 1 13-16 inch in diameter, with a lift of at least 29-64 inch. The pipe in either case should not be less than the diameters of the valves, and if commercial gas pipe is used it will be found that they will both of them have to be 2-inch pipe in order to secure sufficient areas. Although the flywheel should be ample for a two-cylinder engine, when running at the speed you specify, as the engine is evidently intended for an automobile, it would be best to allow for a lower speed, and it is probable that a 200 or 250-lb. rim will be found much more satisfactory. We are quite well aware that the dimensions we give are larger than are used on a good many engines of

this size, but it will be found in every case that if the areas are smaller the engine will be choked.

* * *

Will you kindly give me a little information concerning two-cycle engines? (a) How is the speed of the gases in the engine ports determined? (b) In calculating the power of the engine, should the entire stroke be taken or the stroke minus the width of the ports? (c) Would not the piston displacement be calculated by the latter method? (d) What should be the area of the ports in such an engine having a piston diameter and an entire stroke equal to 4½ inches? (e) What would be the horsepower of this engine? (f) Would a pair of these engines coupled together give more or less power than two such engines acting singly? (g) Is the method of vaporizing gasoline by causing it to drip into a receptacle heated by the exhaust a comparatively new and favorable method of ignition? (h) Should the piston rings for the above engine be made eccentric or by partly turning to size and then cutting out a piece, and afterwards fastening them together and turning them to a circle without their being eccentric?

(a) Assuming that the gases in the cylinder are traveling the same rate of speed as the piston, then the speed in the ports will be as many times as great as that in the

cylinder as the area of the ports is contained in the area of the piston. (b) Usually the entire stroke is taken for convenience and an arbitrary allowance made for that part of the stroke in which the ports are uncovered. In calculating the indicated horsepower of an engine the entire stroke must be taken, as the diagram is obtained for that distance. To be absolutely accurate an indicator-diagram should be taken from the crank-case also, and the area of this diagram subtracted from that given by the gases in the cylinder proper. (c) In calculating the compression space when it is not done by an arbitrary rule, it should be based on the displacement after the ports are covered, provided that the pressure within the cylinder at the moment of port closure is that of the atmosphere. (d and e) These questions can not be answered intelligently without knowing the speed of the engine. (f) Two engines coupled together usually give slightly more power than when run singly, as the mechanical efficiency is slightly higher. (g) There is at least one, if not more, vaporizer working on this general principle. We believe it to be effective, provided the device is properly designed. (h) The eccentric ring has given the best results in practice.

* * *

Please inform me if you know of a two-

cycle gas engine of vertical type with the crank-case at the top and the piston at the bottom. This would be the ordinary two-cycle engine upside down. I believe that this principle would be better for keeping the piston oiled, as the oil would work down against the compression better than up. Kindly inform me if you know of any objection to this arrangement.

We have not heard of such a two-cycle engine, although we see no reason why it should not be operative. The principal difficulty would probably be found in preventing an excess of oil from entering the compression space, which is quite as bad as the use of too little oil.

* * *

Please inform me through your inquiries how to make an effective muffler for a gasoline engine with a 3-inch bore and a 3½-inch stroke.

Take a 12-inch length of each of the following sizes of gas pipe: 1-inch, 2-inch, 3-inch and 4-inch. Cast two heads with grooves in each that will fit the ends of the pipe when placed one within the other. Then drill eighteen ¼-inch holes near one end of the 1-inch pipe, eighteen ½-inch holes in the opposite end of the 2-inch pipe, eighteen ¾-inch holes in the opposite end of the 3-inch pipe and forty-four ⅝-inch holes in the opposite end of the 4-inch pipe,

if it is practicable to exhaust directly from the side of the muffler into the atmosphere. The holes should be so placed that the gases must pass the full length of one compartment of the muffler before entering the next one outside, the exhaust from the engine being carried direct to the 1-inch pipe and entering at the end opposite that in which the holes are drilled. By making the end flanges large enough the muffler may be held together with four 3/8-inch bolts.

* * *

I have been designing a small gas engine and have completed one which runs very nicely, but it does not seem to develop the power it should, although the compression is theoretically 90 lbs per square inch. It is my impression that the intake port is too small for the cylinder, its diameter being 23-100 inch, while the cylinder is 3¼x4 inches, and I desire to run it at 400 r.p.m. The engine generates a little over 1-3 H. P. at 300 r.p.m., and a little more at 400 r.p.m. Will you kindly give me what assistance you can?

There is nothing said about the type of engine, whether it is a two or four-cycle engine, and it will be assumed that it is a four-cycle. The size of an intake port for an engine of this size and running at 400 r.p.m. should be at least .73 inch diameter, showing that the present port is less than

one-third what it should be. The speed of this engine is rather slow for the size, and it is suggested that it be made at least 450 r.p.m., if not 500 r.p.m. At the latter speed the size of the inlet port should be at least .82 inch diameter and the exhaust .89 inch diameter. The power of a gasoline engine of this size should be about 1 H. P. for a four-cycle engine and about 1½ H. P. for a two-cycle engine when the speed is 500 r.p.m.

* * *

(a) Kindly inform me if the time at which the explosion takes place is the moment when the greatest force is exerted on the piston of a gas engine. In other words, if ignition takes place when the piston is at the inner dead center, is the greatest pressure previous to expansion exerted at this point? (b) In a design I have drawn, the ignition takes place when the crank is about 5 to 10 per cent of the stroke over the dead center. Does the greatest pressure take place at this point?

(a) In the ignition of an explosive mixture, such as is employed in the cylinder of a gas engine, there is an appreciable time which expires between the moment when the first particle of gas takes fire and that when the entire mass is fully inflamed and maximum pressure is reached. The length of time depends both upon the proportion

of gas to air and the pressure to which they are compressed before ignition. The majority of gas engine experts contend that the maximum pressure should take place when the piston is at the inner dead center, and in order to obtain maximum pressure at this time it is necessary to ignite the charge before the dead center is reached. This is called giving the ignition lead and the amount of lead required is greater as the speed of the engine increases and also as the compression is increased. It is usually determined for any particular design of engine by experiment. (b) Firing as late as you suggest would probably give you the maximum pressure at a point about one-half way on the expansion stroke and very materially reduce the power of your engine. You should use an indicator.

* * *

Will you kindly tell me if the use of warm air in mixing valves will produce as powerful an explosion as with cold air or air at ordinary temperatures? I enclose this sketch showing how I propose to arrange my mixing valve. What do you think of it?

The use of warm air will reduce the power of your engine and is absolutely unnecessary with a good form of vaporizer. The plan you suggest in your sketch is very crude and a simple mixing valve which you can obtain for one or two dollars will

answer your purpose better and be much cheaper.

* * *

Will you kindly tell me what should be the diameters of the inlet and exhaust valve for a 5x6 inch engine to run at 360 r.p.m.?

Inlet valve 1¼ inches in diameter, exhaust valve 1⅜ inches in diameter.

* * *

I have a 16 H. P. gasoline engine for running a pressure pump in a waterworks, the engine being used only in case of fire. (a) What kind of an igniter would you recommend? (b) Please explain the jump spark.

It is probable that the jump spark would be the easiest to apply in this case, as it is assumed that a tube igniter is now being used; but owing to the fact that the engine is probably in a damp location the jump spark might give trouble unless quite skillfully installed. We should therefore recommend a simple igniter of the hammer-break type, of which there are several on the market which may be attached to any engine. We refer to the magnetically operated make-and-break. (b) We can not spare the space to publish an explanation of the jump spark, and would refer the writer to the "Gas Engine Handbook."

* * *

(a) If the cylinder of a two-cycle en-

gine could be cleared completely of burned gases by means of pure air passing through the cylinder before a new charge is taken in, to what extent would the efficiency be increased above that of the ordinary two-cycle engine? (b) At what speed should the gases be taken in and discharged through the ports of a two-cycle engine, and are there any formulas for computing the sectional areas of these ports for given speed? (c) What is the method of calculating the horsepower required to drive an automobile up a known incline at a given speed?

(a) We have no precise data on this subject, but believe the efficiency would be nicreased from 5 to 10 per cent. (b) 100 feet per second for the inlet, and 85 feet per second for the exhaust. The formulas given in the "Gas Engine Handbook" for a four-cycle engine are also applicable to a two-cycle engine. (c) The ordinary formulas for pulling a weight up an incline are applicable to an automobile when all the conditions of friction losses are carefully considered. Usually it is considered that the friction loss from the engine to the wheel is from 40 to 50 per cent of that given off at the engine crank-shaft. We presume that the inquirer is familiar with this formula, which is given in all text books on mechanics.

The answer to an inquiry in one of the automobile trade papers recently stated that when the cranks of a two-cylinder, four-cycle engine were placed on the same side of the shaft that the impulse in one cylinder takes place at the same time as the exhaust in the other cylinder.

The writer of the answer referred to evidently made the mistake unintentionally, as a moment's thought by one familiar with the cycle would show that the impulse in one cylinder would take place either at the same time as the impulse in the other cylinder or at the same time as the suction stroke in the other cylinder.

* * *

What is the advantage in placing crank-pins of a two-cylinder, four-cycle engine together or on the same side of the crank-shaft? I should think that the better mechanical balance given by having the cranks set at 180 degrees would make a designer invariably select this arrangement.

The sequence of the impulses in the first arrangement has been pointed out in the answer of the previous question. It will be seen that when the pins are together, the impulses occur at regular intervals, while with the pins opposite there will be two power strokes following one another and then two practically idle strokes. The placing of the pins together gives smoother runnnig and requires a smaller flywheel.

Carefully designed bob weights will produce a balance practically as good as when the pins are opposite.

* * *

I have had considerable experience with a two-cycle engine, having built several from my own patterns, and am about to build a three-cylinder 4x4. I would ask you: (a) What dimensions should I make the opening to the crank case? (to be uncovered by piston at top of stroke). (b) What compression would you advise? I want high speed. The engine will be well built and have good, tight rings, with jump spark, with provision for varying the lead. Cylinder heat water-jacketed. (c) Is there any special objection to the jump spark for two-cycle work? I notice it is very little used, especially for marine work.

(a) Make the opening ⅞ of an inch in the direction of the piston travel by 1¼ inches wide, so that the top edge of the port is even with the bottom edge of the piston when the latter is at the inner dead center. (b) Use about 80 lbs. compression, making the length of the compression space 1¼ inches. (c) The jump spark works first rate if the plug is placed in the center of the head, so that the points project into the cylinder and do not get in a pocket. This form of ignition is used quite successfully by several prominent firms of marine work. It works best with an auto-

. matic spark governor that will advance the lead as the speed increases. This engine should give you 15 H. P. at 1,000 r.p.m., and the crank-pins should be set 120 degrees apart. Pains should be taken to get all the three pistons and all three connecting rods of the same weight. If this is done no other balance will be necessary. To get the high speed, do not use the vaporizer with a check valve, but one of the float-feed type in which the gasoline opening is under the control of the needle valve.

* * *

Can a storage battery be charged with a magneto such as is used for ignition purposes?

Yes, provided the magneto is wired to give a direct current and has a sufficient current capacity.

* * *

(a) Will you kindly describe the proper practice for machining the piston rings of a gas engine so that they may retain their eccentricity? (b) What is considered the proper thickness of the crank case of two-cycle engine 4½-inch bore and 4½-inch stroke? What is the usual ratio that may be used for all sizes? (c) Will you please state an efficient way of properly oiling the crank pin and the piston pin in a two-cycle engine, and still avoid a poor explosive mixture and a smoky exhaust?

(a) Divide the machining of the ring into

about four operations. First bore and turn it from the casting, using preferably an inside and an outside tool at the same time; then take a light finishing cut inside and outside and split the ring by milling two square notches in it, giving a lap joint of about ⅛ inch for every inch in diameter of the cylinder bore. Then clamp the ring together so that the ends touch and set them eccentric in a jig, turning four at once, leaving about 1-32 inch over all to finish. Now take each ring, one at a time, spring the ends close together, and take a turn around the circumference with a wire (about No. 20), twisting the ends of the wire together. Then clamp in a jig, remove the wire, and finish the outside with a smooth cut, or by grinding, to the exact diameter of the cylinder. Finally, test the ring in a ring templet bored to exact diameter of the cylinder, and see that the ring has an even bearing about its periphery. See that the piston rings fit with a very small amount of play between the junk rings on the piston. (b) Usually, we should say, about two-thirds the thickness of the cylinder wall. The crank case should be able to stand an explosive pressure of 100 lbs. per square inch, with some allowance for shifting of cores and ample allowance for rigidity. (c) We have experienced no difficulty with splash lubrication, with the oiler feeding through the cylinder wall so

that the opening will be half uncovered by the piston when the latter is at the end of its stroke. A smoky exhaust is due to excessive lubrication, which is entirely unnecessary except in a new engine not yet worn to its bearings.

* * *

I have a two-cycle engine upon which I wish to use a jump spark with the following form of primary circuit maker. This is to consist of a fiber cam in which is to be inserted a steel plate, and contact is to be by two carbon brushes bearing on cam whenever the steel plate touches both of them. I should like to know how wide to make this steel plate for an engine running at 600 feet piston speed.

We would advise you to use a brass plate, since the steel plate is apt to corrode and place an unnecessary resistance in the circuit. Make the width of the plate about one-eighth of the circumference of the cam.

* * *

Will you kindly tell me how to make a spark coil to be used with a hammer brake igniter?

We would strongly advise you not to attempt to make such a coil, but to buy one of a manufacturer of such apparatus. If the engine runs at a particularly high speed use a 6-inch coil. You will find a number of such coils advertised in the columns of *The Gas Engine.*

(a) What diameter and height cooling tank should I get for a 2½ H. P. two-cycle engine run at 400 r.p.m.? (b) What height circulation pipes should be used, and where should they enter the tank?

(a) Use a 75 or 80-gallon tank; 2 feet diameter; 3 feet 6 inches high. (b) Use a 1-inch pipe leading from the bottom of the water jacket to within about two inches of the bottom of the tank, and another from the top of the water jacket to about a foot below the top of the tank. Be sure to use a short piece of rubber hose in both pipes.

* * *

How can the crank-pin be successfully lubricated without weakening the mixture and making a smoky exhaust? Will the splash system interfere with good sparking of the contents?

Lubrication of the crank-pin can be successfully accomplished by splash lubrication if the area of the crank-pin is sufficient. Splash lubrication will not interfere with mixture provided too much oil is not used.

* * *

How can the noisy exhaust of a two-cycle be muffled?

Two-cycle mufflers are not in any way different from four-cycle mufflers, and consist usually of a set of concentric chambers from which the exhaust passes through small holes and flows into the atmosphere from the outer chamber.

What change is necessary to operate a gasoline engine on kerosene?

You will find that a gasoline engine will work quite successfully with kerosene after it has been well warmed up on gasoline. There are kerosene vaporizers on the market, but how good they are we have had no means of determining.

* * *

Should the spark have a 1-16 inch lead at 400 r.p.m.?

The spark lead should be about 20 to 25 degrees at 400 r.p.m.

* * *

(a) What should be the weight of two 22-inch balance wheels for a four-cycle engine having 4-inch bore and a 5-inch stroke, with a 1½-inch compression space? Speed of engine, 400 r.p.m. I have tried to calculate it by the formula in the "Handbook," but evidently do not understand the rule. (b) In a double cylinder engine with the cylinders side by side, is it best to set the crank-pins together or at 180 degrees? (c) If together, and for marine use, should the engine be balanced by weights on the crank webs, and should a lighter balance wheel be used on a single-cylinder engine of the same size?

(a) Assuming that the engine will give 2½ indicated H. P., and that the flywheels are wanted for ordinary service, with a coefficient of .05 the weight of the rims should

be about 110 pounds each. For any other co-efficient the weights on the flywheel should be inversely proportional. For instance, if the co-efficient were .025, the weight of the flywheel rim should be 220 pounds. (b) For a four-cycle engine it is best to place the crank-pins together and it will give a steadier running engine. For a two-cycle engine, place the crank-pins at 180 degrees. If the crank-pins are placed together the engine should be balanced by means of weights placed on the crank webs. (c) A lighter flywheel could be used, provided it would never be necessary to run on one cylinder. It is usual, however, for a two-cycle engine, to use a flywheel large enough for a single-cylinder engine, especially for marine work, in order to carry the crank over the compression when running only one cylinder.

* * *

What formula, if any, is used in determining the dimensions of the inlet and the exhaust port of the two-cycle engine? Please give figures for same (of liberal value) in an engine of 4½-inch bore and 4-inch stroke, to run at 1,000 r.p.m. (b) What should be the minimum amount of drop on this engine? (c) What specific reason can be given that it is better to throttle a two-cycle engine between the crank-case and the cylinder than with throttle on outside of the crank-case? (d)

Would it not be nearer the truth to consider the compression as beginning immediately after the exhaust port is closed on the return stroke at an initial compression of four or five pounds.

A good rule is to make the exhaust port open about one-sixth of the stroke from the end and the inlet port about one-eighth of the stroke from the end. (b) For this engine the exhaust port should open ¾ of an inch from the end of the stroke, and the inlet port ½ inch from the end of the stroke. These ports should be 2½ inches and 2¼ inches long respectively, the bottom of the port being even with the end of the piston when it is at the bottom of its stroke. This gives a drop of ¼ inch, which is the least we should advise. (c) The reason is that a throttle in the by-pass acts immediately, while throttling outside the crank-case makes the control come at the next succeeding stroke. There really seems to be more in it than this, however, as a two-cycle engine controls much better with the throttle in the by-pass than between the crank-case and the vaporizer. (d) A careful inspection of the indicator card and a comparison with the four-cycle engine shows that there is very little difference in the compression stroke for a four-cycle and a properly designed two-cycle gasoline engine.

(a) What power should I get from a four-cycle engine, 5-inch bore and 8-inch stroke, at 250 r.p.m.? (b) What should be the proper compression in pounds and what should be the clearance? (c) Does the hot tube ignition cause premature explosions?

(a) Such an engine would give about 3 H. P. at the speed specified, which is very slow for this stroke. The engine can be economically run from 400 to 450 r.p.m. (b) At 240 r.p.m. we should not recommend a compression pressure of over 60 pounds per square inch. By increasing the speed to 450 r.p.m. it would be quite practicable to use 80 or 85 pounds compression and to make the compression space about 30 per cent of the piston displacement, making allowance, of course, for the volume of the valve boxes or any other openings into the compression space. (c) A hot tube may cause premature ignitions just as any other igniter, if so set as to ignite the charge wrongly.

* * *

I have a four-cycle engine of 60 H. P. with a make-and-break igniter having platinum points. What voltage will the platinum points stand without playing out too much?

We should not advise the use of over 10 volts with a hammer-break igniter. Ordinarily the hammer-break igniter would work well at from 4 to 6 volts.

What should be the thickness of the cylinder walls for a gas-engine cylinder ten inches in diameter?

Practice varies considerably in this regard, but the average practice would indicate ⅞ inch.

* * *

I have a gas engine, using a hit-and-miss governor, and wish to run an electric dynamo with it by adding a heavier flywheel on the crank-shaft opposite the flywheel already on the engine. The present flywheel is 45 inches diameter and weighs 2,000 pounds. The engine is rated at 8 H. P. and runs at 230 r.p.m. What should be the weight of the added flywheel?

A flywheel of the same size as the one already on your engine would probably give you good satisfaction. In order to secure the best results you should use two flywheels weighing 3,000 pounds each. We do not think that the gain would be sufficient to warrant such heavy wheels for your engine.

* * *

I am building a two-cycle, three-cylinder, three-port engine, cylinders 3½x3½, speed 800 r.p.m., jump spark. The engine will be well made and have ground rings. (a) What compression would you recommend? (b) What size inlet port to crank case? (c) Inlet port from crank case? (d) Exhaust port? (e) How much should exhaust port

be opened before inlet port opens. (f) What power should the engine develop at 800 r.p.m.? At 1,000 r.p.m.? (g) What should be crank case compression?

(a) 85 pounds. (b) 11-16x1½ inch. (c) 7-16x1¾ inch. (d) 11x1¾ inch. Top of piston should register with bottom of cylinder ports, when piston is at the bottom of its stroke; and bottom of piston should register with top of crank case port when piston is at top of its stroke. (e) These dimensions will allow exhaust port to open ¼ inch ahead of the inlet. (f) 8 H. P. at 800, 10 H. P. at 1,000 r.p.m. (g) 4 to 4½ or 5 pounds, if possible.

* * *

(a) Does not the horsepower of a marine engine depend on the number of r.p.m. as well as stationary? (b) What is the difference between four-cycle and two-cycle? (I mean horse-power for the same bore, stroke and speed.) (c) Suppose I had an engine rated at 10 H. P. to run at 600 r.p.m., with a 16-inch propeller, would engine give 10 H. P., say at 400 r.p.m., with a wheel large enough to pull her down to speed mentioned?

(a) Insofar as increase of speed increases the power. (b) The two-cycle will give from one-third to two-thirds more power than a four-cycle of the same bore and stroke. (c) If the engine were properly proportioned for 600 r.p.m., the power would decrease directly with the r.p.m.

Hence at 400 r.p.m. the power would be 62-3 H. P.

* * *

(a) Please show how you figure the expansion curve at the points .35, .5 and .75 inch. The Gas Engine Handbook, Chapter XIV. (b) Why do you start with 30 per cent of compression space, when the diagram shows 23 per cent? (c) How do you figure the compression space for the requqired horsepower?

(a) See paragraph at top of page 114. (b) See page 110, tenth line from top. (c) The compression space is based upon the piston displacement, to which it bears a ratio depending upon the compression. The compression varies with the fuel, and also with the design, water-cooled pistons permitting compressions as high as 160 pounds per square inch.

* * *

Will you kindly let me know what size fly wheel to use on a double cylinder, two-cycle 4½x5 inch at 400 to 450 r.p.m.?

Diameter, 16 inches ; weight, about 150 pounds.

* * *

I have a two-cycle, two-port engine, 4-inch bore and 3¾-inch stroke, with both inlet and exhaust port 9-16x2½ inch, both opening at the same time. The engine to run at 800 r.p.m. What size should the ports be?

Inlet port, ½ inch, exhaust, ¾ inch. Make both ports even at the bottom with the top of piston when the piston is at the bottom of its stroke.

* * *

Will you kindly inform me if the following proportions of ports are correct for a two-cycle marine gasoline engine cylinder? A 4½-inch diameter and 4-inch stroke, 500 r.p.m.? Fuel pipe to crank chamber, 1½-inch iron; exhaust pipe, 2-inch iron; inlet port to cylinder, ½x3 inch, exhaust port from cylinder ¾x3 inch.

No. Make inlet 1¼-inch pipe, exhaust 1½-inch pipe, inlet to cylinder ½x2¼ inch, exhaust port ¾x2½, inlet to crank case ¾x2 inches. This engine will run nicely at 800 to 900 r.p.m.

* * *

(a) What is the tensile strength of aluminum castings? (b) How much shrinkage should be allowed per foot in making patterns to be cast in this metal? (c) How big a hole should be bored through the crank shafts and crank arms to oil the pin by centrifugal force? (d) What grade of oil should be used for lubricating the bearing of a two-cycle engine by this method? (e) What is the best bearing metal for the crank shaft? (f) How much packing should be placed between the two halves of crank case (two-cycle engine), allowance being for taking up wear. What is best packing

material in above case? (g) In a cam operated make-and-break ignition device (like that used on the "Locomobile") for a two-cycle engine, how long should the cam be and through how many degrees should the helical cam pass (to attain maximum speed for automobile work), starting with spark at dead center? Also for reversing engine.

(a) The alloys employed in automobile work are about 18,000 to 22,000 per square inch. (b) Seven-sixty-fourths inch per foot. (c) It depends somewhat on the size of the crank, say about 5-16 inch to 3/8 inch. (d) Any high-grade automobile engine oil. (e) A hard phosphor bronze or genuine babbitt. (f) Use one thickness manila paper shellacked on both sides, and renew bearings in case of wear. (g) Not being familiar with the devices, we are unable to answer.

* * *

Will you kindly inform me at what percentage of the stroke of a two-cycle engine the exhaust port should be uncovered?

The exhaust port should open at such a point in the stroke that the pressure of the cylinder will reach that of the atmosphere before the piston starts back again. Usually this may be accomplished by causing the exhaust port to open when the piston has made 90 per cent of the stroke.

Would a cast-steel piston do as well for a gas engine as one made of cast-iron? I should like to make one of cast steel in order to decrease the weight.

It has been the experience of gas engine builders that steel will not stand the abrasive action of the hot gases so well as cast-iron.

* * *

How much play should be allowed for expanding by rise of temperature when fitting a piston in a gas engine cylinder which has a 6-inch bore?

For the best work, the piston should be so fitted in the cylinder that it must be driven in with light taps of a hammer. The piston should then be connected up with the rod and the crank-shaft and the engine run for a day or two by means of a belt from the line shaft. This will wear the piston to a good fit, such as is required for first-class work.

MARINE DESIGN

We are building a gas engine for experimental purposes and would like to ask you a few questions regarding some puzzling points. The engine is an 8 H. P., twin-cylinder, four-cycle, and is intended for driving a boat. (a) We have tried a crank-shaft with cranks set at 180 degrees and find that we get two ignitions on one stroke and none on the other three. Would this trouble be obviated if the cranks were set together and counter-balances employed? (b) The cylinders are 5½ inches diameter and 6-inch stroke. What diameter and what weight should the flywheels be?

(a) Either your igniter is not properly timed, or you have what is known to the gas-engine trade as "back-firing." This is a very troublesome feature in the gas engine, and to it is due a large amount of the trouble experienced with the gas engine. Your engine will run more smoothly with the cranks set together, but should you have an enclosed crank-chamber this arrangement may give you trouble. The igniters should be set to spark while the piston is on its upward stroke and just as it is ⅜ inch from the top of the stroke. (b) The flywheel should be at least 30

inches diameter and should weigh about 300 pounds.

* * *

I wish to build a two-cycle engine suitable for a boat thirty feet long, and would like to know: (a) What horsepower the engine should be. (b) What to make the diameter of the cylinder, the stroke and the speed.

(a) A 6 H. P. engine would be suitable for this size of boat. (b) Make the engine 5¾ inches by 6 inches and run it at 360 revolutions per minute.

* * *

In a marine gasoline engine (a) how is the exhaust pipe finished at the exhaust end when the pipe is carried under water? (b) Is there a muffle pot employed? (c) I understand that there is a kind of check valve used. Could you give me a description of such a valve for a 3 H. P. engine? (d) Why are gas engine pistons made of steel? (e) Would not malleable iron answer for pistons and connecting rods?

(a), (b) and (c) The exhaust pipe is carried up to a point about four inches above the water line under the fantail and then bent downward. The muffler is placed about half way between this outlet and the engine. No check valve is necessary. (d) Gas engine pistons are usually made of cast iron. (e) Malleable iron is not a good material for the purpose.

What should be the dimensions of a 4 H. P. four-cycle marine gasoline engine (bore and stroke), crank diameter, length of connecting rod and crank-pin diameter?

Five and one-half inch bore, 8½ stroke, 300 r.p.m. Crank-shaft 2½-inch steel, pin 2⅝ diameter by 2⅞, rod 16 inches long, 1¾ average diameter of wrought iron.

* * *

(a) I have a two-cycle marine engine, 4⅞ inches diameter, 5½ inches stroke, running at 400 revolutions per minute. What should be the diameter and the pitch for a screw propeller suitable for this engine? (b) Will this engine develop 3½ H. P.? (c) The exhaust port is uncovered when the piston is 1⅝ inches from the end of the outward stroke. Is this the proper distance? (d) The exhaust pipe is 1½ inches in diameter. Is this the proper size? The exhaust ports measure ⅝ inch in the direction of piston travel, hence the piston is one inch beyond the edge of the port when at the end of the outward stroke.

(a) Use a propeller 20 inches diameter and 24 inches pitch. (b) It should develop between 3½ and 4 H. P. (c) We believe this to be a little more of an over-run than is necessary for an engine of this size. (d) The size given is ample. Average practice would indicate 1¼ inches for the exhaust pipe.

What should be the diameter and the pitch of a screw propeller for a two-cycle engine, 5½ inches diameter and 6 inches stroke in order to make the engine develop 4½ to 5 H. P.? At what speed should the engine be run? The propeller is two-bladed and reversible.

The engine should run at 320 r.p.m. in order to develop the power required, assuming that the exhaust port is over-run by the piston one inch beyond its outer edge. Use a propeller 22 inches in diameter, 28 inches pitch. The results to be obtained with the above combinations of engine and screw propellers are suitable for boats of good design. We should advise experimenting with several styles of propellers.

* * *

What is the correct diameter and pitch for a screw propeller with two blades, suitable for a 12 H. P. engine running at 350 r.p.m.?

Use a propeller about 30 inches diameter and 40-inch pitch.

* * *

In a double-cylinder two-cycle marine engine, using jump-spark ignition, how should the wiring be arranged so that the igniters will spark alternately? Is it possible to arrange it without a commutator for both the primary and secondary?

Connect one side of each plug to one terminal of the secondary, then wire the

other sides of the plug to a two-way switch. It will be necessary to make a special switch because of the high voltage of the secondary current. The primary circuit should be closed at the proper time for ignition.

* * *

I am designing a marine gasoline engine of the two-cycle type, with two cylinders, each 4½x4½, and a clearance of 30 per cent of the piston displacement. I should like to have you answer the following questions: (a) At what point in the stroke should the piston pass the exhaust and the admission ports? What are the formulas for the dimensions of these ports and for their location? (b) How many degrees apart should the cranks be set? (c) What should be the diameter of the flywheel and the weight of the rim? (d) Kindly give the following dimensions: Diameter and length of connecting rod, diameter and length of piston and crank-pins, size of crank-shaft. (e) When the exhaust is carried under water will it produce back pressure? (f) Would any benefit be derived from using a condenser? (g) It is necessary to have an air vent in the gasoline tank, and how is it constructed? (h) What is necessary to prevent the evaporation and the disagreeable odor of the gasoline? (i) What should be the diameter and the pitch of a two-bladed propeller for above engine running at 350 r.p.m. for a three-bladed propeller,

and for two two or three-bladed propellers in tandem?

(a) The inlet port should be fully open just at the end of the outward stroke, and the bottom edge of the exhaust port should be just opposite or slightly above the top edge of the exhaust port. Make the width of the inlet port ½ inch and that of the exhaust port 9-16 inch, and make each port 3 inches long altogether, allowing an extra length equal to the width of the crossbars in the ports. The rule for the width of the ports is to make the exhaust port one-eighth the stroke in width and the inlet port one-ninth. The areas of the ports should be such as to give no greater speed of the gases in the inlet than 100 feet per second, and for the exhaust port no greater speed than 85 feet per second. It is not always practical to make the areas as large as recommended, just at the port opening, but usually it can and should be done. (b) 180 degrees. (c) Diameter, 16 inches; weight, about 200 lbs. (d) For the rod, diameter (mean), 1⅛ inches; length, 9 inches; diameter crank-shaft, 1⅜ inches; of crank-pin, 1 9-16 inches; of piston-pin, 1 1-16 inches; length of both pins, 1⅝ inches. (e) A slight back pressure will result, the amount depending upon the depth of the exhaust pipe beneath the water. (f) We do not know of any experiments in this line. The benefit to be derived would

be of doubtful value, as the exhaust pressure is too high above that of the atmosphere. (g) Yes, the vent is usually made by punching a small hole through the cap over the opening. (h) We know of nothing feasible that would at the same time be safe. (i) The engine should run at 450 r.p.m., and at that speed the diameter and pitch of a three-bladed screw should be 22 inches, and for a two-bladed propeller, 24 inches. We are not informed on tandem propellers.

* * *

What diameter and pitch propeller would you advise for a 6 H. P. engine, driving a 30-foot boat?

About 24 inches diameter and 40 inches pitch.

* * *

Permit me to inquire regarding exhaust of two-cycle gasoline engine being carried out under water. If any builders have tried it, what is the effect as to loss of power by back pressure and upon the noise of the exhaust?

This plan is one that has been adopted by one of the prominent manufacturers of gasoline launches, and, it is said, with entire success and without appreciable loss of power. It is claimed that it effectually destroys the noise of the exhaust, although we believe from similar experiments that we have seen tried with the steam engine

that the sound is deadened, but not entirely desroyed. The effective back pressure will be in direct proportion to the distance the engine exhausts below the water.

* * *

(a) What diameter and pitch of propeller should I use on a two-cycle engine with a 5½-inch bore and 5½-inch stroke? (b) At what speed should an engine of this size be run to get the best results. (c) If an engine 5½ inches by 5½ inches and one 5½ by 6 inches were to be placed in hulls exactly alike with propellers of the same diameter and pitch, which engine would be likely to turn up the faster? I have a 20-inch reversing propeller with a pitch of 40 inches which I am using with this engine, and it allows it to turn at a speed of 316 r.p.m. when the blades are set at full pitch. I find that if I reduce the pitch to one-half by turning the blades it allows the engine to run at 404 r.p.m. and the boat will then make a great deal more speed. I am of the impression that a solid wheel will give better results, hence these questions.

(a) We would suggest a two-bladed propeller, 20-inch diameter and 36-inch pitch. (b) The engine should turn this propeller at least 400 r.p.m., and even 425 r.p.m. is not too great a speed for this engine. (c) That with the longer stroke should run at the higher speed, all other things being equal, simply because it has the greater

power. A solid wheel is best, and it should be a true screw with a fairly narrow blade, probably about 6½ inches wide.

* * *

(a) Is it the usual practice in installing gasoline engines in boats to have the exhaust come out the side of the boat? (b) About what position is considered best for the exhaust opening? (c) Is it usual to pass all the cooling water through the muffler?

(a) Yes. (b) It is most frequently placed either under the fantail or just below the top strake. (c) Practice varies in this respect. Some builders do one way and some another.

* * *

(a) Can I obtain good results with a 16-inch solid propeller with a 4 H. P. engine? (b) Should it have three or four blades and of what pitch? I can not swing a larger propeller and wish to use a 4 H. P. engine.

(a) Yes. (b) Three blades will be best for the size mentioned. Use about 28 to 30-inch pitch. If you will send the speed and power of your engine to a maker of screw propellers he will furnish you with the proper wheel.

* * *

Will you kindly advise me regarding an engine I am designing, as I am at sea regarding the compression space required and

also the port openings. The engine is to be a two-cylinder, two-cycle, with a cylinder bore and a stroke each of three inches. It will run at 450 r.p.m. I have calculated the area of the inlet to be .848 square inches and that of the exhaust to be 1.13 square inches, and shall probably make them both of the same area. The compression space I have calculated to 7.0686 cubic inches, assuming that it should be one-quarter of the cylinder volume. Please let me know if these results are correct, and, if not, will you kindly give me the correct figures?

Before answering the above inquiry, we would like to suggest that the speed of the engine be made 600 r.p.m. rather than that chosen. Make the inlet and exhaust port areas each 1.25 square inches for best results, with a drop of ⅛ of an inch. Your computation of the compression space is correct, and will probably give you good results at the speed recommended.

* * *

Will you kindly explain how the speed of a boat is calculated, when all of the dimensions of the boat and size, speed (or any other necessary data) of a gasoline engine are known?

The calculation of the speed of a boat from its dimensions and lines for a certain power is of itself a very long process, requiring the highest class of engineering skill, and even then is a very uncertain pro-

cess. Nearly all designers depend upon judgment and experience as much as upon calculations. Two boats may be to all appearances alike, and in fact be built on what seem to be the same lines, yet one will be a tub and the other a racer. This, however, has been more the case with sailing craft than with power boats. For large vessels, such as men of war, a model is first made, carefully following the lines of the intended boat and using a scale of exact proportions. These models are then experimented with in a special tank, using some of the most delicate instruments that are obtainable, and from the results of these experiments the speed of the boat is calculated. Thus, you see, that it would be quite difficult for us to give you any rule that would be at all reliable.

* * *

(a) How fast should a 20 H. P., two-cycle engine drive a 42-foot boat with 7-foot beam? (b) What pitch and diameter propeller would you recommend for such a boat? (c) At what speed should the engine run?

(a) We have seen a boat of this description make nearly thirteen miles an hour by the log. (b) Thirty inches diameter, 50 inches pitch. (c) For a two-cylinder engine about 350 to 400 r.p.m.

* * *

I wish to fit up a launch for shallow

waters, using a propeller, and understand that there is some method of doing this called "turbine propulsion." Can you give me any information on this matter or direct me to some literature on the subject?

The Thornycroft propeller described in his work on Marine Engineering has been used with much success for this purpose. A still later plan is to make a half tunnel under the stern of the boat in which the propeller lies about half submerged when the boat is not in motion. As soon as the propeller starts it immediately fills the tunnel with water submerging itself. This plan has been proved quite successful and is very simple.

* * *

What should be the pitch and diameter of three-blade propellers for a 4 and a 6 H. P. two-cycle engine, to run at 400 and 350 r.p.m. respectively How much lead should the igniters have on the above engines?

Twenty-inch diameter and 36-inch pitch, and 24-inch diameter and 43-inch pitch. About 20 degrees measured on the crank circle.

* * *

(a) What horsepower should be obtained from a 6-inch by 8-inch marine engine? (b) What should be the diameter of the crankshaft? (c) What should be the diameter of the flywheel? (d) What should be the clearance space between the piston

and the cylinder head? (e) What should be the size of the inlet and the exhaust ports and valves?

(a) Assuming a speed of 325 r.p.m. the engine will probably give as high as 6 H. P. (b) The diameter of the shaft should be 2¼ inches. (c) The diameter of the flywheel should be 24 inches, and should weigh about 250 lbs. (d) If the valves open directly into the cylinder the clearance space should be 2½ inches long. (e) The inlet valve should be 1⅝ inches diameter, and the exhaust valve 1¾ inches diameter. However, for convenience in machining, they may, without materially reducing the power of the engine, be made both 1⅝ inches diameter. For both inlet and exhaust, 1½-inch pipe will answer, provided long and tortuous passages are avoided. In case it is necessary to carry the exhaust a long distance, a 2-inch pipe should be used.

* * *

(a) What should be the size at the crank-shaft of the valve and flywheel in a double-cylinder marine engine, 6-inch bore and 7-inch stroke? (b) With a 2-inch length of compression chamber what power will it develop at 350 r.p.m? (c) Is it best to place the crank-pins opposite?

(a) The crank-shaft, if made of good steel, should be 2 inches diameter, the crank-pin 2¼ inches diameter by 2¾ inches

long, and the inlet valve for 350 r.p.m. should be 1 9-16 inches diameter and the exhaust valve 1-11-16 inches diameter. The flywheel should be 22 inches diameter, 4½-inch face, with a rim 4½ inches deep. (b) The engine should develop 11 B.H.P. at 350 r.p.m. for a four-cycle engine. (c) It would be best to place the crank-pins on the same side of the shaft, and to use bob weights for a counterbalance.

* * *

I wish to inquire what horsepower you would expect to get from a four-cycle marine engine, 3 inches by 3 inches, at 550 r.p.m., and 3¼ inches by 3½ inches at the same speed, compression 60 pounds per square inch, 12-inch flywheel, jump-spark ignition?

For the 3-inch by 3-inch, slightly under 1 H. P.; 1.3 for the 3¼-inch by 3½-inch. It should be noted that 550 r.p.m. is a comparatively slow speed for so small an engine. If the valves are large enough the engines could be run up to a speed of 800 or 900 r.p.m., or even higher.

* * *

I am building a 35-footer, with torpedo stern, and wish to make a speed of from 12 to 15 miles per hour, the faster the better. Will you kindly tell me about what equipment you can recommend, so that I can have a basis for my inquiries to manufacturers? I might say in conclusion for

your guidance that it is not so much a question of price, as it is getting what I want.

In the first place we would advise you to see a boat builder who has already succeeded in making fast boats, giving him a full outline of your requirements and the waters in which you expect to operate your boat. Then rely upon him for choosing the size of the boat and the power of the engine to a great extent. We should suggest increasing the length to 40 feet and securing an engine of the modern high-speed type, preferably a four-cylinder, to give at least 30 B. H. P. at the speed the engine is to run in the boat. A four-cylinder 4½ by 5 two-cycle will when running at 1,000 r.p.m., give you required power. If the engine is of the four-cycle type it should be 5x6 inches, with jump-spark ignition and an automatically regulating vaporizer and muffler of ample proportions, and an exhaust carried beneath the water under the torpedo stern. Use a solid propeller with reversing mechanism inside the boat. so arranged that the engine can be detached entirely from the propeller shaft for starting. You will find that some makers will object to these specifications, but if you want to be up to date insist upon them. Use a propeller which is a fine screw with narrow blades. If your boat

is built on good lines it should, with such an engine, on smooth, deep water, give you a speed of about 13½ or 13 miles an hour and possibly more.

* * *

(a) I would like to ask you a few questions about a four-cycle double-cylinder marine gasoline engine of 4-inch bore by 4¼-inch stroke, giving about 68 pounds compression before ignition. What horsepower would this engine give at 800 r.p. mm.? At 1,000 r.p.m.? (b) What should be the diameter of the crank-shaft? (c) What should be the size of the flywheel? (d) How large should the valves be and how far should they open? They are placed on the side and near the top of the cylinder, the inlet valve being directly over the exhaust valve and opened atmospherically. (e) How large a two-bladed propeller wheel do you think this engine would turn at 800 to 1,000 r.p.m. so as to develop the full power?

(a) Six H. P. at 800 r.p.m. and about 8 H. P. at 1,600 r.p.m. (b) One and one-half-inch diameter. (c) About 15 inches diameter. (d) Inlet valve 1⅜-inch diameter, 11-32-inch lift. Exhaust valves 1½-inch diameter, ⅜-inch lift. (e) This engine should turn a two-blade propeller about 13 inches diameter by 26-inch pitch if the general lines of the boat will permit it. It should be remembered that the

propelier is a matter of experiment and you may have to try several before one is obtained that will suit the boat.

* * *

Please give the following information in connection with a 3x3 two-cycle marine gasoline engine:

(a) Size of inlet and exhaust ports and amount of drop. (b) Length of compression space. (c) Size of shaft. (d) Would 9 inches be sufficient diameter for the fly-wheel? (e) If so, give width and depth of rim for that size. (f) What power would engine give at 600 revolutions? (g) Would you advise greater speed? (h) Would jump-spark or hammer-break be best means of ignition?

(a) In direction of the piston travel make the inlet ⅜-inch wide and the exhaust ½-inch wide, making both 1½ inches long. Locate the ports so the bottom of each will be even with the top of the piston when the latter is at the bottom of its stroke. (b) One inch. (c) One inch. (d) Twelve inches is preferable for such a small engine. (e) For 12-inch rim about 2-inch face and 1¾ inches deep. (f) Two H. P. at 1,000 r.p.m., 1.2 at 600 r.p.m. (g) We should advise from 1,000 to 1,200 r.p.m. (h) We should recommend the jump-spark with proper protection from dampness.

What horsepower should be derived from a 4½x6-inch four-cycle engine at 400 r.p.m., compression space 27 per cent, inlet 1-inch diameter, exhaust 1¼-inch diameter? (b) What would be the compression and the probable explosive pressure? (c) What size boat would this engine be suitable for?

(a) From 3 to 4 H. P. (b) About 100 pounds compression and 400 maximum pressure. This compression is too high for such a slow-speed engine. The compression space should be reduced to about 30 per cent of the piston displacement. (c) Twenty-five feet long over all.

* * *

Am designing and building a 7x7½-inch four-cycle, four-cylinder gasoline engine. (a) What size shaft should use? (b) Also please give me the formula for computing shafting for multi-cylinder engines. (c) What B. H. P. will this engine develop at 400 r.p.m.?

(a) Two and one-half inches diameter. (b) A four-cycle, four-cylinder engine takes the same size crank-shaft as a single-cylinder, provided the impulses are evenly distributed around the crank-circle and the thrust is at no time any greater than would be the maximum in a single-cylinder engine. (c) Thirty-five B. H. P.

I am building a four-cycle engine, 4¼-inch bore and 6-inch stroke. (a) What should be the diameter of the valves and their lift for a speed of 500 r.p.m.? (b) What power should the engine develop at that speed? (c) Is this speed correct? (d) What part of the stroke should compression take place?

(a) Inlet valve 1⅜-inch, exhaust valve 1½-inch. Make the lift one-fourth the diameter of the valves. These calculations are for a speed of 600 r.p.m. (b) The engine should develop 4 H. P. at 600 r.p.m. and about 3 1-3 H. P. at 500 r.p.m. (c) For a boat the engine should run from 500 to 600 r.p.m., and for an automobile about 800 r.p.m. (d) This question is meaningless. The writer probably refers either to the time of the ignition or to the length of the compression space. The lead of the igniter should be about 30 degrees for 600 r.p.m. and the volume of the compression space from 25 per cent to 30 per cent of the piston displacement.

* * *

(a) Two-cycle vertical marine single-cylinder, 6½x6½ inches. The exhaust port is ⅝-inch wide in the direction the piston travels and extending about 9 inches around the cylinder circumference. It begins to open when the piston

is 7/8-inch from the lowest point and is completely opened when the piston is 1/4-inch from its lowest point. The inlet port is 1/2-inch wide in the direction of the piston travel and extends about .9 inches around the cylinder circumference, same distance as exhaust. It begins to open when the piston is 1/2-inch from its lowest point, and is completely opened when the piston has reached its lowest point. There is one valve, the mixing valve, located on the crank-case, make-and-break ignition. (b) What should be the length of the compression space? (c) Will this run at 800 r.p.m. and maintain its efficiency? If not, what changes are necessary so that it will, and also run at a wide variation of speed, 800 r.p.m. not to be the extreme limit? (d) What power should it give at 800 r.p.m.?

(a) Your ports are too narrow for a high-speed engine; They should open 1 1-16 inch. Usually the piston gets to the inlet port 13-16 inch before the piston gets to the bottom of the stroke. To secure high speed you should use a piston-opened inlet in the crank-case, which is closed when the piston is 1 1/4 inches on its downward stroke. (b) The length of the compression space should be 1 15-16 inches. The proper areas of the port are given by the "Gas Engine Handbook." (c) The engine will run at the speed spec-

ified. (d) If properly designed and constructed it should give at least 17 H. P. at 800 r.p.m.

* * *

Will a four-bladed (or fluke) propeller wheel give less vibration than a two or three-bladed wheel, assuming that each was accurately designed?

It is claimed by marine engineers that a three-bladed wheel gives the best balance.

* * *

I am laying out a 4x5-inch marine engine, and being in doubt about some of the dimensions, I have made a list as follows for your criticism. Will you kindly look this over and let me know what you think of them?

Four-cylinder, 4-inch bore, 5-inch stroke. What power at 600? What power at 1,000?

Valves inlet, 1¼ inches; exhaust, 1⅜ inches.

Compression chamber, 1½ inches (1½ inches long, 4 inches diameter).

Cylinder walls, 5-16-inch thick.

Water jackets, ½-inch.

Crank-shaft, 1½ inches in bearings, 1⅜ inches end.

Crank-pin, 1½ inches diameter, 1⅝ inches long.

Piston pin, cold-rolled, ⅞-inch diameter, ⅜-inch hole through center.

Flywheel, 16 inches diameter, 100 pounds.

Connecting rod, 1-inch mean diameter, 8½-inch centers, or shorter if possible.

Stock in base, ¼-inch thick.

The power of this engine should be 12 H. P. at 600 and 20 H. P. at 1,000. We find all your dimensions quite good, with the exception of the flywheel, which should be about 150 pounds total weight, and the connecting rods, which we would prefer to see made 9 inches, center to center.

* * *

(a) On a two-cycle motor, when the gasoline fuel enters the crank-case, what kind of a check valve is advised between carbureter and motor? (b) On a two-cycle, two-cylinder gasoline marine motor —now built—can you suggest a method to have the bottom port "piston-opened?" (c) Are not piston-opened ports on two-cycle motors subject to wide ranges in speed, and is not this one of the chief recent improvements in this class of motors?

(a) Use a light form of valve opening upward with a very light spring. (b) Make the length of the piston at least 1 1-5 times the stroke, and make the size of the crank-case ports in the direction of the piston travel 1-5 time that of the stroke. We can not see how this can be

done without making a new cylinder. (c) Yes.

* * *

(a) With a propeller large enough to overload a two-cycle engine until its r.p. m. were four-fifths of what it should be, could a second engine (duplicate) be coupled direct and still not have too much power for the same propeller? (b) Would the crank-shaft of the "aft" engine need to be heavier than necessary for its regular work or would it do? (c) If the crank-shaft were strong enough, is the idea of "direct connecting" two 2 H.P. two-cycle engines practical? (d) Would this differ essentially from a double-cylinder engine?

(a) We believe that the propeller would run one-third faster with the second cylinder. We do not believe it will have too much power. (b) No, the same size crank-shaft will answer. (c-d) The scheme is perfectly practical and would not differ essentially from a double cylinder engine.

* * *

In a 5x6 two-cycle marine engine, at what point should I place a pet-cock for relieving compression in starting?

Place cocks at half stroke.

I have a small two-cylinder automobile engine which is a four-cycle, air-cooled; size of cylinders 2x5-inch, and fitted with a piston make-and-break igniter. (a) Do you think the motor could be installed in a small boat to run with any sort of satisfaction? I can cool it with a small fan. If you think it could be done, what size two-blade propeller would you advise and at what speed? (c) What horsepower would it develop at that speed?

(a) There should be no trouble with the engine in a small boat, provided a fan was used to cool it. (b) As the bore and stroke of the engine is so unusual we believe some mistake must have been made in the measurement. Making a rough guess we should say about an 18-inch two-bladed propeller. (c) Not being sure of the bore and stroke we could hardly tell what horsepower the engine would develop.

* * *

I am designing a trading vessel 60 feet long, 12 feet beam and 8 feet depth of hold, full model, with good lines fore and aft, for service around the Gulf coast. The engine will be a four-cylinder upright fitted for crude (Beaumont) oil; size of cylinders 8x14 inches. This stroke is rather long for marine use, but I have patterns for this size and my experience is that a more reliable service, with much less re-

pairs, is obtained with a longer stroke and less revolutions than with the short stroke, strenuous high-speed motors. The above refers, of course, to where you have the room to install the longer stroke. Above engine will be fitted with governor and speeded to 300 r.p.m. (a) What size screw with 1½ pitch ought this engine to handle at that speed, with boat drawing 4½ feet? (b) Would you advise two or three blades, and would you consider 1½ pitch about right? (c) With a screw of the right diameter and pitch, what speed can I expect with this vessel? (d) Do you consider 90 pounds compression for crude oil the best practice? (e) Will above engine work up to 60 H. P. at 300 r.p.m., and is a 1,000-pound flywheel, 30 to 36 inches diameter, sufficient?

(a) Not knowing the lines of the boat we can figure the wheel only approximately, but we believe a wheel 5½ feet in diameter and 6½ pitch would be all right. It is probable that you would have to try several wheels before you get one that will suit your boat. (b) We believe three or four blades would be better for a cargo vessel. (c) We judge about 12 miles an hour. We believe that 90 pounds is a little high for this, and 75 to 80 pounds would be about as high as the oil will stand, or until you just avoid premature ignition. (e) The engine should give

60 H. P., and will possibly give 65 H. P. at the rated speed, provided she is in good working condition. A 600-pound flywheel with a mean diameter of 30 inches will be ample for this engine.

* * *

(a) What would be the horsepower of a four-cycle marine gasoline engine, 4-inch bore, 5-inch stroke, running at 650 r.p.m.? (b) What diameter and what weight flywheel would it be practical to use and get good results?

(a) Three H. P. (b) Fifteen inches diameter. About 120 pounds.

* * *

(a) Is the following correct for the rules of the American Power Boat Association? "Area piston in inches by stroke in feet by r.p.m., divided by 150," and should the speed be taken at full lead of propeller, propeller having reversing blades? (b) How far ahead of the dead center should the spark be advanced to obtain the best results? (c) The builders say my engine should turn 600 r.p.m with full load on propeller and develop 3 1-3 H. P. I can get only about 350 r.p.m. and less than 1½ H. P. Can you help me? The engine is a 4x4-inch. (d) Will the engine give greater speed with the jump-spark than with the make-and-break, and is the jump-spark reliable?

(a) The formula is correctly stated, but

this denominator is too small; it should be 825. (b) About 30 at 600 r.p.m. (c) Your trouble is probably due to having too bluff lines in your boat; and, as you say it is an auxiliary, we are quite convinced that this is the cause of your difficulty. (d) Generally speaking, yes, because of the ease with which the lead can be adjusted.

* * *

I am constructing a double-cylinder two-cycle marine engine, 7-inch bore 5½-inch stroke, exhaust port 1x3¾ inches, inlet port 11-16x3¾ inches, connecting rods 13 inches between centers, flywheel 22 inches diameter, 4½-inch face. There will be perfect suction and compression in the crank-case, no loss whatever through shaft-bearings. The compression space is 1⅝-inch; the engine is to run at 500 r.p.m. (a) Do you think these measurements will give satisfactory results? (b) How much B. H. P. should this engine develop? (c) What size propeller and what pitch should this engine turn for a boat 40 feet by 7 feet 3 inches?

(a) Make exhaust ⅞x4-inch, inlet 11-16 x4-inch, rods 11-inch, center to center. The other dimensions are O. K. (b) Twenty-two H. P. (c) It will depend somewhat on the boat, but we would sug-

gest a propeller 18 inches in diameter, 28-inch pitch.

* * *

(a) What is the best point for opening and for closing the exhaust and inlet valves of a four-cylinder, four-cycle marine engine, 8¼-inch bore by 9-inch stroke, running at 450 r.p.m., and also when running at 500 r.p.m.? (b) What should be the lift of each valve and what should be the diameter for the best results? Is 3-inch diameter large enough? (c) There is only 2½-inch clearance on top of the piston with no valve chambers the valves being in the head. Is this correct? (d) What should be the diameter of the inlet and the exhaust pipe? (e) Is it possible to get as much power by the exhaust of the four-cylinder into one pipe, or should two independent pipes be arranged? (f) Is 450 to 500 r.p.m. fast enough to gain anything by holding the exhaust valve open past the top center, as advocated for automobile engines? (g) Is there any gain with a mechanical inlet at that speed?

(a) We should open the exhaust ⅞-inch in advance of the end of the expansion stroke and close it at or slightly beyond the top center. Open the inlet valve slightly after the exhaust closes and close it ¼-inch up on the compression stroke. (b) At 450 r.p.m. the inlet should be 2¾-

inch diameter. At 500 r.p.m. make the inlet 3-inch diameter and the exhaust 3¼-inch diameter. Make the lift in each case at least one-fourth the diameter. (c) This is about right allowing for counter bore. (d) Use pipes with opening equal to the valves of 3-inch pipe in each case above. (e) There is no advantage that we know of in using more than one exhaust pipe. (f) On this size engine we think there is a slight advantage. (g) We advise the mechanical inlet by all means.

* * *

I am building an engine, four-cycle marine, with opposed cylinders, 5½x5-inch stroke. What horsepower should it develop at 400 revolutions and what at 600?

Eight H. P. at 400 r.p.m., 12 H. P. at 600 r.p.m.

* * *

(a) What will be the proper place and size for crank-case port for a two-cycle marine gasoline engine, cylinder 3¾-inch bore 3½-inch, stroke 600 r.p.m.? (b) The flywheel is 13¾-inch diameter weight 75 pounds, rim 3x3 inches. Do you think this is right?

(a) The crank-case port should be 1½ x⅝-inch, the smaller dimension in the direction of piston travel. Make the top of port and bottom of piston even when

piston is at top of stroke. (b) Yes, about right.

* * *

What should be the diameter and the pitch of three-bladed propellers for 6, 8 and 12 H. P. engines, running at 600 r.p.m.?

Eighteen in. diameter, 30 in. pitch; 20 in. diameter, 34 in. pitch; 24 in. diameter. 40 in. pitch.

* * *

I am having built a sailing yacht, 32 feet long, 50 feet o. a., 12-foot beam, with 7,000 pounds ballast in the keel. I wish to equip this boat with a gasoline engine, and ask the following questions relating thereto: (a) What horsepower will be required to give this boat a speed of 7 miles per hour, and what horsepower to give 9 miles per hour? (b) As weight and speed are important considerations, I would like to know whether you would advise a two or a four-cycle engine? (c) What is the danger of using gasoline? (d) What safeguards should be taken in connection with the tank feed pipe and engine? I believe your book does not give any special directions on these points. I propose to have a strong copper tank with swash plates to drain to feed tank. Copper drip pan with scupper to carry off any leakage. Two vents to tank in case one might be covered. Tank to be in waterhead bulkhead

near the bow. The after bulkhead to be lined with asbestos as protection in case of fire in the galley. A tight partition to be built two or three inches under the deck and lined with asbestos as an air chamber and precaution against excessive heat and sun. A stopcock at the tank always to be kept closed when the engine is not running. Tank to be thoroughly fastened and covered with a wooden casing to open top and sides. The galley to be well ventilated to give a good current of air and carry off any possible collection of gas and leakage. Feed pipe of lead or copper from tank straight to keel to below the engine, then lead or copper pipe up to engine. Exhaust under water. Propeller with two solid blades and reversing gear, the blades to turn up behind stern post when boat is under sail. (e) I am told that a three or four-bladed propeller might give one-half mile more speed, but that there is considerable vibration when allowed to revolve under sail.

(a) We should judge it would require about 12 to 15 H. P. to give such a boat the speed of 7 miles per hour. We do not believe a higher speed should be attempted, as it would require too large an engine. (b) We should judge a two-cylinder engine of the two-cycle type, although a four-cycle will give you good service. The amount of space and the weight of these engines should be obtained from a manu-

facturer's catalogue, and this will permit you to choose between the two types. (c) The greatest precaution to be taken in handling gasoline is to prevent its leaking into an enclosed space where it will become mixed with air and form an explosive mixture. (d) We believe your plan is a very good one, although we see no necessity for boxing in the engine if the cabin in which it is placed is well ventilated. We believe you would do better if you made your connection from the tank to the engine with a ⅜-inch lead pipe for the entire distance, making all connections with first-class wipe joints made by a good plumber. (e) The two-bladed propeller is best suited to your purpose. The difference in speed between the two-blade and that given by three or four will scarcely be noticeable.

* * *

(a) Please inform me if the following proportions are right for a three-cylinder engine, with 6-inch bore and 6-inch stroke, running at 600 r.p.m., the engine to be a two-cycle. The inlet and the exhaust ports are to be of the same size, the passages being 2½ inches diameter, and the areas of the ports 4.8 square inches. The drop is to be ⅜ inch, and the compression space about 30 per cent of the piston displacement. It is proposed to use jump-spark ignition. In order to reduce the weight as much as possible, I propose to use an

aluminum crank-case, water jacket and fittings. (b) What size propeller should this engine be capable of turning at this speed?

(a) The proportions are very good, and will surely give excellent results if the mechanical work is carefully done. (b) We should judge that a 24-inch propeller, having a pitch of 2½ inches, would be right for this engine. However, the diameter and pitch of the propeller depends not only upon the speed and power of the engine, but to a certain extent on the line of the boat.

* * *

I have a launch under construction, 28 feet over all by 5 feet 3 inches beam. I have a two-cylinder engine, 4½x4½ inches. (a) What power should the engine develop at 400 r.p.m.? (b) At 450 r.p.m.? (c) What size and what pitch of propeller should I use to obtain the fastest speed? speed?

(a) For a two-cycle engine, 2.3 H. P. (b) 2.6 H. P. (c) 16 inch diameter, 28 inch pitch. (d) Amidships.

* * *

(a) What would be the horsepower of a two-cylinder engine 5-inch bore by 5-inch stroke when running at 600 r.p.m.? (b) What would be the proper sized flywheel for such an engine for marine purposes? (c) What should be the areas of the inlet and the exhaust ports, and what should be their width in the direction of the piston

travel? (d) Would this engine be large enough for a 35-foot boat to run between nine and ten miles an hour?

(a) The engine should develop 11½ B. H. P. when working at its best. It would be safe to rate it at 9 H. P. (b) Use a 16-inch flywheel with a rim 4 inches wide and 3 inches deep when measured toward the center. (c) The area of inlet should be 2 square inches and the area of the exhaust 2.35 square inches. Make the width of the exhaust port ⅞ inches and that of the inlet port 9-16 inch. (d) With a boat having very fine lines you might possibly get nine or even ten miles per hour. It would be safe, however, to add another cylinder, and then you can depend upon ten miles an hour with a boat having fair lines.

* * *

(a) What should be the horsepower from a two-cycle 3½-inch by 3½-inch engine, running at 450 r.p.m.? (b) Would it answer for a 21 feet by 4 feet 6 inches boat? (c) The engine has a 12-inch flywheel weighing about 38 pounds. Would it help it any to put on a 16-inch flywheel weighing about 60 pounds?

(a) About 1 1-3 H. P. (b) The engine is quite small for such a boat. We should recommend at least a 4-inch by 4-inch. (c) If the engine runs steadily with the

present flywheel the only advantage in changing would be to make it possible to slow down to a lower speed. We would suggest putting a finer pitch screw, and turn the engine up to 700 r.p.m. or more.

AUTOMOBILE QUESTIONS

I wish to build a gasoline engine to drive a motor carriage. (a) What should be the size of the engine and its speed? (b) What power would it give when doing its utmost?

(a) Use an engine with a cylinder 4 inches in diameter and with a 5-inch stroke. The maximum speed should be about 500 revolutions per minute. (b) About 3 H. P. The engine is supposed to be intended for a carriage suitable for two persons.

* * *

(a) How many separate and distinct methods of automobile propulsion are in use at the present time? (b) What motive power is considered the best for the purpose?

(a) Three principal methods are in use at present, with several more in sight. These three are electricity, gasoline engines, and steam. Compressed air is in sight, and is being used to some extent in an experimental way, while there has also been a proposition to employ liquid air. (b) Of the three first mentioned, electricity is used more for cabs and other public conveyances, and gasoline and

steam for suburban and interurban driving. For all-around work gasoline is at present the best. Steam once threatened to push it hard, but we think that the gasoline carriage has come to stay, and that it will outlast its competitors.

* * *

(a) What should be the diameter and the stroke for a two-cylinder four-cycle engine to develop 6 B. H. P. at 600 r.p.m.? (b) What should be the weight and the diameter of a flywheel for above engine? (c) What should be the diameter of the crankshaft and the crankpin?

(a) 4x6. (b) 45 pounds should be the weight of the rim for one flywheel, diameter 18 inches. (c) Crankshaft of steel, 1.5 inch diameter; crankpin, 1.75 inch diameter.

* * *

What should be the cylinder diameter and the stroke of a vehicle engine with two cylinders and of the two-cycle type to develop 6 H. P. at 600 r.p.m.?

3·75x3·75·

* * *

If an automobile is going at a speed which requires the entire power of the engine, and the dead load were to be

doubled, what would be the effect upon the speed of the vehicle? Take the case where the automobile weighs 1,000 pounds, and there is no change in the ratios of the driving gears.

Theoretically, the power required varies as the product of the speed and the load. With a gas engine running under the conditions you name, and without change in the reducing gear, any additional load added to the vehicle after the engine had reached its full power would stop the engine altogether.

* * *

Will you kindly give me the following figures for two-cycle opposed automobile engine 3¾ inch by 4 inch, at 1,000 r.p.m., single inlet to crankcase, size of inlet and exhaust ports, size of inlet to crankcase, and size of throttle tube at spraying nozzle when an auxiliary air inlet is used in the vaporizer?

Exhaust ¾ inch by 2⅝ inches, inlet to cylinder 9-16 inch by 2½ inches, inlet to crankcase ⅞ inch by 3¾ inches, throttle tube ⅝ inch diameter.

* * *

Which is preferable, to have the cylinder head cast on or bolted on, in a four-cycle automobile engine, 5¼-inch bore and 6-inch stroke?

We should prefer a head that is bolted on for this size engine, for the reason that

it is much easier to bore clear through a cylinder than from one end only. However, quite a number of engines are made with heads cast on the cylinders.

* * *

(a) I would like to know what are the correct dimensions of the crankcase inlet, cylinder inlet and exhaust port for a high-speed two-cycle auto engine 4½-inch bore and 5-inch stroke. (b) What should the water jacket space be and also diameter of inlet and outlet pipes? (c) What should the compression space be? (d) I intend to place the spark plug on the inlet side of the cylinder, and when the piston is at the end of the compression stroke it will be cut off from the rest of the compression space, except by a space of ¼ inch between the end of the deflector and cylinder head. Would it work successfully?

(a) Crankcase inlet 1 1-16 inch by 1¾ inch; cylinder inlet ⅝ inch by 2 inches; exhaust 15-16 inch by 2 inches. (b-c) Water jacket space ½ inch, inlet 1¼ inch, outlet 1½ inch, compression space 1 7-16 inch long. (d) Place spark plug in the center of the cylinder head for best results.

* * *

What diameter and what weight flywheel should be used for a 4¼-inch bore,

4-inch stroke, two-cycle automobile engine, 800 r.p.m.?

We would suggest a flywheel about 16 inches diameter and weighing at least 120 pounds.

* * *

(a) I have a four-cycle 4x4-inch auto engine which I intend to place in an 18-foot launch, speed 200 to 1,600 r.p.m., 4 I. H. P. What should be the weight of the rim of flywheel 16 inches in diameter at center of gravity of rim? (b) From formula No. 22, page 163, of the Handbook using the mean speed of 900 r.p.m., weight equals

$$\frac{4 \times 1116000000000}{16^2 \times 900^3 \times .15} = 47.8 \text{ lbs.}$$

Isn't this too light? (c) Did I use the proper number of r.p.m.? (d) Would it be advisable to use drawn steel tubing ¼ inch or 5-16 inch thick, 2½ inches or 3 inches in diameter for the cylinder of a four-cycle motor? (e) Would cast iron pistons work well in such cylinders? Could they be successfully cooled by using ⅛ or ¼-inch copper or steel pins screwed into the sides, and if so, how deep and how far apart should I drill the holes?

(a) We would suggest a 90 or 100-lb. flywheel for this diameter. (b-c) The trouble is due to taking too high an r.p.m.

figure. Your flywheel at about 800 r.p.m. for a launch or automobile engine, using the horsepower that can be given at that speed. (d) Drawn steel tubing is not satisfactory for gas engine cylinders, for the reason that it will cut. (e) We do not see the advantage of an air-cooled engine in a launch, as you always have the water near by. In case you used an air-cooled engine you would have to use a fan to cool it successfully. If pins are used they should be put as close together as it is possible to place them.

* * *

What is the utility of the yoke in place of the connecting rod on high-speed automobile engines?

We would not recommend the use of a yoke for a high-speed automobile engine; we believe the connecting rod is much better.

* * *

Which engine is the best for automobile use, the water-cooled or the air-cooled? And will the air-cooled keep cool enough to run good without the aid of fans? I am going to buy an automobile soon or buy the parts and construct it myself, and am rather in favor of the air-cooled engine, but am not posted on them. All the cars around here are the water-cooled. I would be pleased to hear from anyone who is posted on this subject.

Both water-cooled and air-cooled engines are showing good service. An air-cooled engine larger than 3¾ bore should not be operated without a fan, and we consider that an engine even of this size or smaller is better with a fan in extremely warm weather.

* * *

(a) I am about to build an automobile engine of the two-cycle type, with two cylinders 4½ by 4½. The inlet and the exhaust ports each contain eight ⅜-inch square holes, and I will use a ¾-inch exhaust pipe. Are these dimensions sufficient? (b) Can I use fins instead of a water-jacket on an engine of this size?

(a) These openings are too small for an engine of this size. The speed of the engine is not given, but it is assumed that it will be 600 r.p.m. In that case the area of the inlet should be 1.25 square inches and that of the exhaust 1.5 square inches. It would, therefore, be necessary to use 1¼-inch pipe for the inlet and 1½-inch pipe for the exhaust. We would advise increasing the dimension of the holes, measured along the length of the cylinder, to ½ inch. (b) The cylinder is too large for cooling by fins.

* * *

(a) What should be the size flywheel necessary to use on a 2x3 engine, two fly-

wheels of the web type being employed? (b) How many revolutions should the above engine make?

(a) Assuming that the engine is to be used for an automobile, we should recommend that the flywheel be 9 inches outside diameter and about 10 pounds of metal should be put in each flywheel rim. This is on the assumption of 1,000 r.p.m. as the normal speed of the engine. (b) This engine should run satisfactorily up to 2,000 r.p.m., provided the walls and passages are proportioned for that speed.

* * *

(a) Which system of automobile transmission absorbs the most power by friction, a chain or the gear drive? (b) Do you think there is any end thrust in a shaft drive which jams the teeth and causes friction? I may purchase an automobile soon, and have not yet made up by mind which system, as a whole, is best.

(a) While new, a clean chain gives the least friction, but when the chain is dirty and worn the gear drive has the advantage, provided it is properly designed. (b) There is both end thrust and side thrust in a bevel gear drive, which is usually taken care of by ball bearings.

* * *

What is the internal arrangement of the mufflers used on automobiles, especially those that make the least noise?

The general principle of this class of muffler is to change the direction of the current as often as practicable before the exhaust reaches the atmosphere. They are usually made of a number of concentric cylinders (four or five). The exhaust passes from the engine to the interior cylinder through holes at the end opposite the point of entrance to the next cylinder, then to the opposite end of this one through holes in the next, and at last it passes from the outside cylinder to the atmosphere. The total volume of the muffler should be at least 4½ times the displacement of the piston.

* * *

(a) What should be the size of a chain for driving an automobile weighing approximately 1,700 pounds and using a 12 H. P. engine? (b) Would you recommend a roller or a block chain? (c) What should be the sizes of the sprockets when driving the rear wheels direct from the engine on the fast or direct-connected gear? (d) I propose to use 32-inch wheels with 3½-inch detachable tires. Would you consider this combination to be the right one?

(a-b) Use a roller chain having a 1¼-inch pitch. (c) Use an 8-tooth and a 26-tooth sprocket. (d) The proposed combination, while somewhat expensive, will

give very easy riding. 30-inch wheels and 3-inch detachable tires would give fair satisfaction, but not so good as the sizes proposed.

PRODUCER GAS QUESTIONS

(a) What is the proper compression for an engine running on producer gas? (b) What power would we likely get out of a three-cylinder engine, 13x14-inch cylinders, running 170 r.p.m., with everything in good shape? The engine is a Westinghouse gas engine, 125 B. H. P.

(a) The proper compression of a producer gas engine depends on the chemical composition of the gas, which varies to some extent, according to the fuel used in generating the gas. The compression runs from 150 to 230 pounds (absolute) per square inch. (b) The power secured from this engine would depend on whether or not the engine has been designed for use with producer gas, or whether it is a "city gas" or natural gas engine converted to the use of producer gas. In a paper by Mr. Wyer will be found the following: "No gas producer plant can be successful unless the gas engine is adapted to suit the particular gas available for its use. On the authority of Westinghouse, Church, Kerr & Co., an engine which will develop 100 H. P. with natural gas will give only about 80 H. P.

with producer gas, a loss of about 20 per cent. With a 200 H. P. engine this loss would be about 15 per cent, and with sizes above 300 H. P. it would be about 10 per cent. Hence the obvious necessity of designing the engine to suit for the particular fuel it is to use. Several failures have been made by neglecting this important point." If, therefore, the engine referred to is rated at 125 B. H. P. on natural gas, it could not be expected to develop over about 100 B. H. P. on producer gas.

* * *

Relative to gas producers, (a) how many pounds of steam are required per pound of coal? (b) How many pounds of air per pound of coal? (c) What per cent of sulphur may a coal have and not seriously injure the engine? (d) In case of a coal with an excessive amount of sulphur, how is the gas purified? (e) What is the maximum velocity of gas through the generator and auxiliary apparatus?

(a) The steam supply should be calculated to furnish about two pounds of steam for each pound of coal consumed in the generator. The exact amount of steam can not be determined in advance; it must be adjustable according to the requirements of the process. Too much steam reduces the efficiency of the generator, as it cools down the burning coal too much, or may extinguish the fire altogether. The mini-

mum is about three-fourths pound of steam for one pound of coal. (b) Only so much air should be admitted as is necessary to keep the producer going. About one-tenth to one-sixth of the total amount of coal goes to keep the fire burning. In order to burn this part of the coal completely, about twelve times its weight of air is required. Consequently, from 1.2 to 2 pounds of air must be supplied for each pound of coal. An excessive amount of air injures the economy of the producer. (c) The anthracites used in European producer practice contain on an average of from .085 to .29 per cent of sulphur. The highest amount known of is 4.1 per cent. This does not damage the engine as far as could be ascertained. (d) In order to purify the gas obtained from a coal containing more than the above named percentage of sulphur, it will be necessary to provide a purifier of the same kind as is used in illuminating gas plants. Its contents should be so calculated that the gas travels at the rate of from 55 to 75 feet per hour. (e) The maximum velocity of the gas in the various apparatuses depends upon their size and design, which in turn are calculated upon the size of the engine and the combustible to be used. In the pipes the maximum theoretical velocity of the gas is about 5,000 feet per minute.

(a) Referring to page 32 of Haenssgen's Suction Gas, about what is the difference in level of the water in the pressure gauge glasses for the different parts of the system? (b) What thickness of sheet metal is used in making the scrubber, generator, etc.? I suppose it varies with the diameter of the shell.

(a) The glasses referred to are largely for comparative use. Of course, when the plant is at rest the heights should be the same in all cases, as there is no suction or pressure in the system. If any one passage becomes considerably clogged up, the gases can not flow through as rapidly as they should when the suction is effected, and the gauge glasses behind this passage will show a slower action than the glasses ahead of it. The difference in any one plant would depend on its construction. (b) The thickness of the shells varies not only with the diameter, etc., but also with the manufacturers, just as does the amount of jacket space vary with engine builders. Some of these generators, etc., are made with cast iron, in which case the thickness is much greater.

GENERAL QUESTIONS

In looking over the catalogues of several dealers in gas engines I find that some recommend the electric igniter while others are equally prejudiced against it. (a) Is the electric or the hot tube igniter the most reliable and why? (b) Is there any advantage in the use of a small dynamo for producing the current for the igniter?

(a) Both the electric and the hot tube igniters have their advantages. The electric igniter is not so successful when the engine is to be put in the hands of ignorant persons, for simple as this device is they will persist in doing everything else but following the instructions sent with the engine. It has the advantage, however, of leaving no flame of any kind exterior to the engine. It also saves the fuel that would otherwise be employed in heating the tube. Expense of keeping up the battery is less than the cost of the fuel and of new tubes. The tube has the advantage of being a device that is easily understood, and hence can be handled by any one. It is, however, apt to burn out at inconvenient times, and until the advent of the nickel steel tube the tube had to be renewed every few days. (b) The small dynamo saves the

battery, and is always ready for use if properly cared for. The engine must be started with sufficient speed to generate the current, so that with large engines it must be used in conjunction with a battery. This arrangement has still an advantage over the battery alone, as a cheaper cell may be used and will last a long time, as it is required only for starting the engine.

* * *

Is it best to make a special engine for using gasoline, or is it sufficient to use a gas engine with gasoline attachments?

It is not necessary, as, aside from the gasoline attachments, the engines are usually identical.

* * *

(a) What is the best way to set the igniters on a gasoline engine? (b) Are tube or electric igniters best?

(a) The best way to set an igniter is by the aid of the indicator diagram. The igniter should be set just so far in advance of the return stroke as to give a diagram with a nearly straight explosion line. It is a difficult matter to set the igniter properly without the aid of the diagram, and if a rule were given in terms of the stroke, say so much of the length of the stroke ahead of the center, it would be correct for one speed only. (b) The electric igniter is fast replacing all other forms of ignition.

(a) Can an ordinary gas engine be fitted with an attachment so that it will use ordinary kerosene? (b) Would the use of kerosene increase or decrease the power of an engine as compared with gasoline? (c) What is the best form of igniter for kerosene?

(a) We believe that with the use of a tank carbureter and by warming the fuel it is possible to run an ordinary gas engine with kerosene. (b) The horsepower of such an engine using kerosene is about five-sixths of that obtained when using gasoline. (c) Both the electric and the tube igniter have been employed with success for kerosene, the kerosene-engine makers seeming to favor the "jump spark." It is a fact worth mentioning that kerosene will ignite from a hot surface at a much lower temperature than will gas.

* * *

In fastening wires into porcelain insulators for use with the "jump spark," what cement should be employed to fasten the wire into the hole and the brass cap on the outside of the tube?

We believe that a cement made with plaster of paris and a saturated solution of alum is employed for porcelain. We are not certain that this cement will answer your purpose.

Is there a reliable means of igniting the charge in a gas-engine cylinder without the use of a battery?

Yes, you may employ a small dynamo, either of the direct-current type, or that known as the magneto, in which the current is alternating.

* * *

What is a jump spark and how is it produced?

A jump spark is one of such high pressure that it will arc across a considerable space. It is formed by means of an induction coil, of the kind that is popularly known as a Ruhmkorff coil. The current is sent from the battery through the primary circuit, and this circuit is closed at the proper time for ignition of the charge by a switch on the cam shaft, producing a stream of sparks as long as the switch is closed. This method of ignition is becoming quite popular, especially with the motor-carriage builders.

* * *

Is there any relatively simple method of testing gasoline? If there is, will you kindly outline it briefly, and state what constitutes high-grade gasoline?

Gasoline is usually rated in the arts according to its specific gravity on Beaume's scale. It is tested by means of a hydrometer marked in degrees according to the arbitrary scale adopted by Beaume. Gaso-

line for gas-engine use is what is commonly called stove gasoline, having a specific gravity of 72 degrees Beaume. In winter many engines use 74-degree and 76-degree gasoline.

* * *

(a) What is the best method for wiring up two gasoline engines using jump-spark ignition, a dynamo and an induction coil being employed? (d) What is the best ignition plug for this purpose? The porcelain plugs I have used seem to short-circuit after a few explosions and do not spark properly. (c) How should the switch be arranged in order to change the lead of the spark?

(a) In case but one induction coil is employed it will be necessary to place a commutating switch in the secondary circuit. (b) As you have had trouble with porcelain, we advise you to try lava. (c) Arrange the brushes on the primary switch in such a way that they may be rotated around the switch.

* * *

I find best to have the spark occur before the piston reaches its highest point. How far from the end of the stroke should the piston be when the spark occurs?

The best way to set the igniter is by means of an indicator diagram; but it is not an easy matter to make a diagram, especially when an indicator is not avail-

able. The following empirical rule will be useful: Set the igniter so that it will spark at a point in advance of the stroke equal to one-sixteenth the length of the stroke in inches. Then for an engine with a 4-inch stroke the lead of the ignition should be one-fourth inch. The lead depends upon the speed of the engine, as well as the length of the stroke. It is variously given by gas-engine designers anywhere from 10 degrees to 22 degrees of the crank circle in advance of the dead center. The lead is greater with a longer stroke and less with a higher speed.

* * *

Please let us know the best material for packing and to prevent leakage on gasoline pumps and valve-stems on gasoline supply pipes.

The best material for this purpose has been found to be wicking lubricated with ordinary brown soap.

* * *

(a) What is the principal objection to a jump spark? (b) Can the ignition be timed as accurately as with make-and-break? (c) Will dampness cause sparking without closing circuit?

(a) The principal objection to a jump spark is that, owing to the poor electrical engineering which is employed in connection with the installation of the apparatus

and its design, it has given considerable trouble. The troubles are short-circuiting of the secondary, breaking down of the coil, burning off the contact-points on the interrupter, owing to insufficient capacity in the condenser and in many cases unreliable ignition because of attempting to use a long, thin spark in the secondary rather than a short, fat one. (b) Yes. (c) We do not understand this question, but take it to mean, "Will dampness cause sparking without making a dead short circuit?" If this is what is intended by the question, we would say that dampness may close the circuit and cause a spark at an undesired time. Dampness will also cause trouble by short-circuiting in the secondary, allowing the high-tension current to leak from one wire to another, and thus prevent a spark from passing between the plub terminals.

* * *

When using a gas engine under ground in a gaseous mine, is there not danger of igniting the mine gases from the exhaust of the engine? It would seem to me that the continuous presence of fire would make such a motor a very dangerous one for use where there is much firedamp.

The inquirer seems to have a misconception of the operation of the gas engine, as he presupposes the presence of flame at end of the exhaust pipe. The exhaust is usually

led through a muffler, and has to go a considerable distance before it reaches the mouth of the exhaust pipe. By that time it is comparatively cool, and the hand may be held in front of the exhaust pipe without serious discomfort. When a gas engine is used in which the mixture is ignited by electricity, a flame is a no time present on the exterior of the engine.

* * *

Will you kindly decide the following? "A" owns a launch 20 feet long with 5-foot beam, and "B" owns a launch 22 feet 6 inches long with a beam 5 feet 6 inches. Both are equipped with a 3½ H. P. motor, running at 375 r.p.m., and each has an 18-inch, two-blade reversible propeller. The two launches have been built by the same company and have the same lines. The engines are identical, being two-cycle, single-cylinder motors built by the same makers. Which of the two launches, when carrying four passengers, should run the faster in still water, the conditions of the atmosphere being the same in each case?

If all conditions are practically identical except the length on the water line and the breadth of the beam, the shorter boat would have the advantage. The advantage possessed by the smaller boat is obvious when the comparison in size is made greater, as for instance if the larger boat had twice

the length and twice the beam of the shorter.

* * *

(a) How can I magnetize the field magnets for small magneto-electric igniter? (b) Can it be done with an alternating current supplying electric lights?

(a) The best way to magnetize permanent magnets is to stroke them with another permanent magnet. Lay the bar to be magnetized upon the work-bench or other convenient place, and with one end of the permanent magnet stroke it from the center toward one end five or six times. Then reverse the magnet, and with the *other end* stroke the bar from the center toward the end not already operated upon. (b) You can not magnetize the bars with an alternating current.

* * *

(a) How should a jump sparking device be wired for a double-cylinder two-cycle engine, with cranks at 180 degrees, and giving two impulses at every revolution of the crank-shaft? The ordinary methods would work with opposed cylinders, but ours are horizontal, and the difficulty is to avoid an explosion when one piston is down. (b) How would this difficulty be obviated with a two-cycle opposed cylinder (double-acting) tandem engine?

(a) We presume that the inquirer in-

tended to say vertical instead of horizontal. When cylinders do not run with their cycles in time so that the explosions in each occur at the same moment, the secondary of the jump spark system must be commutated, *i. e.,* switched from one spark-plug to the other. If there are more than two cylinders it may be found advisable to increase the number of coils. If the coil is operating practically all the time, a storage battery should be used to supply the current. (b) See answer to (a).

* * *

I am desirous of obtaining information regarding the jump-spark method of gas-engine ignition. (a) Is the jump-spark method as effective as the ordinary make-and-break? (b) What are the proper dimensions of the induction coil, sizes of wire, etc.? (c) Is as strong a primary battery required as with the older method? (d) What is the proper distance between the sparking points? (e) How should the terminals be insulated? (f) Should one terminal be connected directly to the engine. as with the make-and-break igniter?

(a) If properly handled, yes. (b) We prefer not to give directions for making a spark-coil for this purpose, as to do so would require more space than is at our disposal in these columns. The sizes of wire are by no means the most important

features. A successful coil depends upon the manner of winding, insulating, etc. We advise purchasing a coil designed expressly for this purpose. (c) About the same. (d) Use a ½-inch spark-coil and place the terminals about ⅛ inch apart. (e) With good porcelain or with mica. (f) No.

* * *

To what extent is it advisable to vary the ignition lead in a two-cycle engine?

The answer to this question can be obtained only by experiment with the engine. In general, it may be given a lead that does not cause it to fall off in power. Make the limit such that with a greater lead no more speed may be derived from the engine under its normal load when the throttle is wide open.

* * *

What is a convenient way of testing for compression?

Turn the engine over by means of the flywheel. If a spring balance be hooked to a point upon the rim and the pull noted, the compression may be found by drawing a diagram of the parts and computing the resistance upon the piston by graphical methods. The most satisfactory method would be by means of an indicator.

* * *

(a) What is the method of calculating the amount of power required in a gas-

engine pumping plant to pump a given amount of water to a given height?

The theoretical horsepower required for pumping water is found according to the following formula:

$$HP = \frac{62.5\ Q\ H}{33{,}000}$$

wherein Q equals the volume of the water in cubic feet pumped per minute; H equals the head in feet. The actual power required to drive the pump is from 10 to 40 per cent greater than the theoretical, and it depends upon the efficiency of the pump and the resistance of the pipes. The head H should be measured from the surface of the water at the source of supply. For example, if it required to pump 1,000 cubic feet of water per minute to a height of 100 feet, the power required would be

$$HP = \frac{62.5 \times 1000 \times 100}{33{,}000} = 189 \text{ H.P.}$$

Adding 25 per cent to this result to make up for pump friction and the resistance of pipes, etc., the power required would be 236 H. P. For a full discussion of friction losses see any engineer's pocketbook.

* * *

Will you kindly inform me which is the best oil for gas engine use—a vegetable or

a mineral oil, or a combination of both?

Mineral oils have been found the best for gas engines. Animal or vegetable oils become carbonized at too low a temperature for the purpose. When these are employed the oil will be destroyed by the high temperature in the engine before they can lubricate it properly.

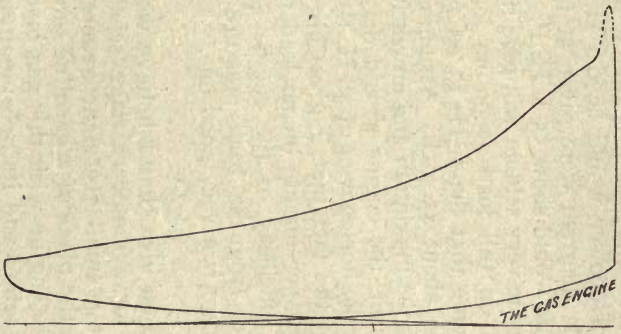
* * *

At what movement of the firing pin is the spark developed that fires the charge?

The movement which causes the firing pin to break the circuit is that when the spark is made. In other words, the spark occurs immediately after the pin on the piston strikes the firing pin.

* * *

I send you enclosed an indicator diagram taken from a 35 H.P. gasoline engine, which I was called upon to test a short time ago. The diagram shows that the exhaust valve did not open at the right time, but this was afterwards corrected. The cylinder is 13 inches diameter by 20 inches stroke and was running at 200 r.p.m. The card was taken with a 160-lb. spring. The engine would give about twelve impulses per minute when running without a load. (a) What is the indicated horsepower of the engine? (b) What is the actual horse-



Diam. 13 in.
Stroke, 20in.
Speed, 200.
Spring, 160
Impulses, 12 per min.

power and the efficiency of the engine as near as can be told from the data given? (c) What is your opinion of the card outside the fact of the back pressure shown? This engine was installed to take the place of a 40 H. P. steam engine, and has been doing the work to the satisfaction of the owner.

(a) The diagram shows a mean effective pressure of 96 pounds per square inch, and with twelve impulses per minute the indicated horsepower would be 6.6 H. P. If this same diagram were given at full load the engine would show 55 I. H. P. A gasoline engine very seldom will give the same diagram on full load as on no load, and we presume that the I. H. P. on full load would be about 45. (b) Assuming 45 I. H. P. as the maximum and an efficiency of 85 per cent, the engine should develop an actual brake horsepower of 38 H. P. Judging from the fact that it gives but twelve explosions per minute on no load the mechanical efficiency of the engine is good. (c) Aside from the back pressure shown, the diagram is a very good one.

* * *

I have an idea that I believe would be feasible for a motor carriage scheme. It is to put a small acetylene generator on board in the place of a gasoline tank, and to run the engine with this gas instead of using gasoline and its accompanying an-

noyances. I should like your opinion whether it is a good one or only an idle dream.

We are inclined to think that this scheme might at least be worth trying. It could easily be calculated what extra weight, if any, would be necessary to carry in the shape of apparatus, water, etc., needed for such a device. It would appear at a casual glance, however, that the advantages to be obtained would be more than offset by necessity of having to carry a greater amount of cumbersome apparatus than is required with the gasoline carriage.

* * *

I have a 25-H. P. steam engine which I would like to change over into a gas engine. Can this be done with any measure of success?

It is quite possible to so alter a steam engine that it will operate successfully as a gas engine. In fact, it has been done in several cases, and we know of a gas engine manufacturer who started his business in this manner. Such an alteration would, however, give you a gas engine having less power than you can get with your steam engine. We are of the opinion that it would be a better plan for you to sell your steam engine and boiler and put the proceeds into part payment for a good gas engine. The altered steam

engine would not give you the same economy or cause you as little trouble as an engine built and designed for using gas.

* * *

Which of the following three methods of handling the gasoline is the most reliable, the carbureter, the gravity feed or the pump feed? Which of the three systems is the most used?

Each of the three systems mentioned is in use, and is the best for the purpose to which it is applied. The carbureter appears to be the favorite for motor carriages, because it is not seriously affected by a jar. The gravity system is the favorite for launches and the lift system for stationary engines. The reason of the preference for the lift system in the latter case is because it is practically required by insurance regulations, as they stipulate that the tank shall be underground and at a distance from the engine. We believe that the lift system is that most used.

* * *

What degree of gasoline is the most satisfactory to use?

Usually 72 deg. is desired, but in very cold weather 74 deg. or even 76 deg. is occasionally employed. As a matter of fact, much of the gasoline sold is 68 deg., even when marked a higher test.

What sort of a coil is needed for a jump-spark?

A Rhumkorff coil.

* * *

I have an offer from a boat-building firm to make a launch 45 feet long, fitted with a 20 H.P. engine under a guarantee of 12 miles per hour in still water. I have seen a great many gasoline launches that made what was supposed to be 12 miles per hour, and even more, but on timing them on a measured course they nearly always fell short of the speed claimed for them. I wish to ask for your opinion on the subject, as to whether it is safe for me to enter into a contract with any chance of securing such a speed. Will you kindly give me this information in your inquiries column?

If the maker has an established reputation, and you can make a contract with him guaranteeing the speed or no sale, you may get it. Such boats have been built, and can be built again. The power, however, has usually been nearer 30 than 20 H.P. Many engines are rated below the power they are capable of developing under careful handling. The writer recently timed such a boat, or one approximately the same size, which gave 12.7 miles per hour under somewhat adverse conditions.

I wish to know of a paint that I can use on the exhaust pipe, black preferred, that will not burn off with the heat.

The following paints have been recommended as being able to withstand anything up to a red heat, and as therefore suitable for painting exhaust pipes and mufflers: Lampblack, 3 pounds; graphite, 3 pounds; black oxide of manganese, 1 pound; Japan gold size, 1 pint; turpentine, ½ pint, and boiled linseed oil, 1 pint. Powder the graphite, and mix all the ingredients to a uniform consistency. Give two coats. Or black oxide of manganese, 2 pounds; graphite, 3 pounds, and terra alba, 9 pounds. Mix and pass through fine sieve. Then mix to required consistency with the following compound: Sodium silicate, 10 parts; glucose, 1 part, and water, 4 parts.

* * *

Why does too much oil in the cylinder prevent explosions?

Excess of oil dampens the spark or destroys it altogether, by getting on the igniter electrodes.

* * *

How does a ground joint answer for gas engine cylinder heads?

It is sometimes used, but is more expensive than the asbestos gasket, and a ground joint is more trouble to repair, because the studs must be removed whenever it is reground.

I have an engine with cylinder 10¾ in. by 15 in. stroke, running at 190 r.p.m., using carburetted water gas of approximately 550 B.T.U. I would like you to answer the following questions: (a) What brake horsepower should this engine develop under the conditions named? (b) How many horsepower should it take to run the engine empty, that is, without driving any load except itself? (c) What consumption of gas per horsepower should this engine use when fully loaded; when about half loaded; and running empty?

(a) About 15 H.P. (b) Assuming a mechanical efficiency of 80 per cent, it would take about 4 I.H.P. (c) Engines vary greatly in this respect, and, without knowing the make and the date it was manufactured, it would be difficult to answer this question. For a good modern engine the consumption would be about 18 cubic feet at full load, 22 cubic feet at half load, and 25 cubic feet empty. These figures are for indicated horsepower.

* * *

(a) Will ask that you kindly inform me as regards the specifications for lubricating oil for gas engine cylinders, the specific gravity, flashing point, etc. We have found much trouble in using steam engine cylinder oil for lubricating gas

engine pistons. (b) What is the difference between gas engine cylinder oil and "crank-case oil?"

(a) A suitable gas engine cylinder oil should have a flashing point not below 400 deg. F.; should burn not below 475 deg. F., and should have a specific gravity of 24½ deg. below Baume, at 60 deg. F., and a viscosity of over five minutes per 100 c. c. at 77 deg. F., as measured with the Engler viscosimeter. (b) By "crank-case" oil we understand a common or fair grade of machinery oil, having a flashing point at 350 deg. F. or over, and burning point of 400 deg. F. or over, and a much lower viscosity test at ordinary temperatures.

* * *

(a) In what proportion should gasoline and air be mixed to get the most perfect combustion? (b) What temperature does it explode at best? (c) What is the chemical composition of the result of the explosion. (d) Are any solids or liquids left from the explosion which would tend to clog up the machinery? (e) What is the relative volume of the mixture before and after the explosion? (f) What would happen if a number of charges were forced into a cylinder and the explosion delayed until the pressure caused by forcing these charges in was raised to 25 or 50 pounds?

(a) One hundred and twenty-four volumes of gasoline to 1,000,000 of air. (b) The editor does not understand this question thoroughly, but assumes it to mean the temperature to which the charge should be brought before ignition to get the best effect. This brings it down to a matter of the best compression, and this should be as high as may be obtained without the charge taking fire of itself. At normal speed, about 600 feet per minute, the limiting compression for gasoline is between 80 and 90 pounds per square inch. (c) As gasoline consists entirely of hydro-carbon the result of perfect combustion is a mixture of carbon dioxide, water vapor (steam) and nitrogen. (d) Imperfect combustion will cause a deposit of carbon in the cylinder and the exhaust passages. Carbon will also deposit from an excessive amount of lubricating oil when this is but partially consumed. (e) In a gas engine there is practically no change of volume at the time of the explosion, but instead a rise of pressure in the ratio of about 4½ to 1. (f) Nothing unusual would happen in this case, not any more than what occurs when the pressure is raised by the usual compression in the gas-engine cylinder.

* * *

Will you kindly explain what is the difference between naphtha and gasoline?

As generally understood, the terms ars synonymous. Strictly speaking, however, naphtha is synonymous with petroleum that is obtained in the Russian oil fields. As a trade term it is employed by the oil refiner to designate a series of products obtained in the manufacture of kerosene, or what is obtained in the distillation process after all the benzine is given off and before kerosene is obtained. There are three grades of naphtha, known to the trade as A naphtha, B naphtha and C naphtha, of which C naphtha is the lightest. To the consumer these products are usually known as gasoline, the medium and heavier grades being always employed to operate gasoline engines, the lighter varieties being employed for steam automobiles and in painters' gasoline torches.

* * *

How is the pressure at the time of combustion calculated when the compression pressure is known, so as to get the theoretical horsepower of the engine?

The pressure after combustion or the maximum pressure in the cylinder is from 3½ to 4½ times the pressure of compression, according to the fuel employed. For very weak fuels, such as blast furnace gas, it may be even less. For gasoline and natural gas it runs from 4 to 4½ times the compression pressure.

Did Beau de Rochas or Otto invent the gas engine as now sed?

Nearly all modern writers credit the invention of the four-cycle engine to Beau de Rochas as he described it in 1862, or fourteen years sooner than Otto put the principles enunciated by the former into a practical working engine.

* * *

I read in a recent publication on automobiles that two-cycle engines could not be run over three or four hundred revolutions per minute. Don't you think that the writer is misinformed, as I find that the catalogues of marine engine builders give speeds as high as 500 revolutions for a small engine.

The writer referred to made a very serious mistake when he published this statement. Recent experiments of which we have definite knowledge show that there is no more limit to the speed of a two-cycle than there is to a four-cycle engine. In fact, we have seen a two-cycle engine that would develop practically the same power per revolution when running at 1,000 r.p.m. as it would when running at 400 r.p.m. In other words, if the engine would develop 4 H.P. at 400 revolutions, it would develop 10 H.P. at 1,000 revolutions.

* * *

I recently had an argument with a

friend of mine who claims that a gasoline explosion can not be caused by a spark from a cigar or a cigarette. I showed him an account of an explosion on Long Island Sound, which the newspaper said was produced by a spark from a cigar. In this case it was the gasoline tank of the launch that let go. In spite of this account my friend still sticks to his side of the argument and suggests that I write to your paper about the matter. Will you kindly give me what information you can about the matter and oblige a constant reader?

Your friend is quite right, and the newspaper reporter must have drawn on his imagination or else was misinformed as to the cause of the accident. Gasoline will not take fire from either a lighted cigarette or a lighted cigar.

* * *

Why is an auxiliary exhaust put in some four-cycle engines for the exhaust at the end of every stroke?

To relieve the strain on the exhaust valve and more effectually clear the engine.

* * *

Is there any other packing besides asbestos that will answer the purpose?

Sheet lead or copper has been used for this purpose with success.

We have a marine engine of 35 H.P. that turns a certain three-blade propeller at 275 r.p.m. We tried the wheel with another engine of different make, rated by its builders at 45 H.P. The latter engine, its builders claim, should make 340 r.p.m. Will you kindly explain this inconsistency?

Very few manufacturers rate their engines according to the actual maximum horsepower that they will give at a speed which they are designed for. For instance, an engine which is capable of 35 H.P. at 275 r.p.m. may give as high as 45 or 50 H.P. when the power is actually measured. If the 35 H.P. engine will give just that horsepower at 275 r.p.m., and the engine will not choke itself when running at 340 r.p.m., it will at the higher speed give a little bit over 43 H.P. It looks as if the 35 H.P. engine were underrated, and that the 45 H.P. was rated at nearly its maximum horsepower at the given speed. If both of these engines are rated at their maximum horsepower, the 45 H.P. engine will be able to turn the propeller at the same speed as the 35 H.P.

* * *

What is meant by lead of a spark? Should it be before or after the piston leaves the upper dead center?

The lead of the ignition means igniting

before the piston gets to the top of the stroke. When the igniter fires the mixture at the dead center it is said to have no lead. After the piston has started on its downward stroke it is said to have negative lead.

* * *

Will you kindly tell me how I can find the mean effective pressure of any gas engine?

This is possible only by taking an indicator diagram, getting the mean effective pressure from this in the ordinary way. You will find the methods of doing this explained in works on this subject.

* * *

What temperature should the exhaust water of a marine gasoline motor be?

About 150 degrees F.

* * *

(a) Can a steam engine indicator be used on a single cylinder, four cycle gas engine? (b) If not, what changes must be made? (c) How is the piston motion connected to the indicator?

The indicator for a gas engine is usually provided with a piston of one-fourth inch area to stand the high pressure developed. (b) The makers of indicators can usually furnish necessary attachments for this purpose. (c) You can usually employ a rod fastened on the piston so as to project above it. This method is illustrated

in Fig. 39, page 184, in the "Gas Engine Handbook."

* * *

(a) At what temperature F. may kerosene be converted into gas and used in place of gasoline?

(a) Kerosene vaporizes at from 300 to 575 deg. F. It is not, however, necessary to bring the kerosene up to this temperature for use in the engine. After an engine has got hot by starting on gasoline it will usually run successfully on kerosene, and even some of the other distillates. Ordinarily kerosene engines draw in the air from around the exhaust pipe or air shaft surrounded by hot water from the engine.

* * *

(a) Will a kerosene engine with automatic ignition, such as hot heads, chambers or tubes, run smoothly under the following conditions: For example, if the engine is a 50 H.P. and the fuel valve is set so that the engine runs smoothly and evenly when under full load, then if all the load but about 5 H.P. be thrown off, will they run as smoothly on this light load and continue so for probably an hour or more without making any change whatever with the fuel valve or paying any attention whatever to the engine? I should think the cylinder head would cool off on continued light load and affect the

timing of the ignition, thus requiring a richer charge, necessitating a change of the fuel valve or the pump regulating the charge so small as to be very lean in mixture. (b) Would not electric ignition be more satisfactory? (c) Also, can kerosene be vaporized satisfactorily by induction into the cylinder, being vaporized by the current of air drawn in? This to be done without hot heads, chambers or heat of any part of cylinder or exhaust. Would this give a good mixture? I have always been under the impression that kerosene would not vaporize satisfactorily without the aid of heat, such as hot heads or heat from the exhaust. I have lately heard of an engine having an electric spark and a mechanical vaporizer by suction running with kerosene. (d) Would not a gasoline engine run smoother and govern better under light loads, having a hit and miss governor holding the exhaust open, rather than one which only lets the fuel valve stay closed, allowing the cylinder to scavenge, thereby changing the condition of the mixture of the next charge? These questions are some derived from conditions which occur in a stone polishing plant which we run by gasoline engine.

(a) The engines you refer to do not, as a rule, run smoothly on light load for exactly the reasons you mention. (b) Elec-

tric ignition has been used successfully in quite a number of kerosene engines. (c) Usually some method of heating the kerosene or the air before entering the engine is employed, such as drawing the air from around the hot exhaust pipe. (d) So long as the fuel valve is closed absolutely we do not believe there will be a great deal of difference in the operation of the engines. However, if there is a sight leak in th fuel valve there is apt to be an overcharge of fuel when running by cutting off the fuel instead of when holding the exhaust valve open.

* * *

I am taking the liberty to write you for some information in regard to concrete foundations for gas engines from 100 H.P. Please give me the proportions of Portland cement, sand and broken stone, and also what effect freezing weather would have on the concrete, and also state what effect salt would have if it is used in the mixing of the concrete.

The usual proportions for Portland cement are to one of the cement, two of ground sharp sand and five parts of gravel or broken stone. Concrete must not be laid without salt in freezing weather. Salt is used a great deal in laying of concrete in winter to the amount of about 5 per cent of the water used, however, it is not best to use salt if it can be avoided, as it does not in any way strengthen the con-

crete and its hygroscopic action tends to keep the foundation damp in wet weather.

* * *

Will you kindly inform me by what means indicator cards are taken in the largest gas engines, and how high the measured pressures run?

Indicator cards for large gas engines are taken by means of an indicator like the ordinary steam engine indicator, but with a ¼-inch area piston and a specially heavy pencil movement. Practically all indicator manufacturers make gas engine indicators. The pressure runs as high as 400 to 450 pounds for the maximum initial pressure.

* * *

What is lowest compression that will give an explosion?

Explosions will occur at atmospheric pressure.

* * *

A three-cylinder marine engine turned 250 r.p.m. with a make and break of spark. It was changed to a jump spark and then turned 20 revolutions faster than had ever been possible with a hammer-break spark. (a) What is the cause? (b) A four-cylinder automobile engine with jump spark turned 800 r.p.m., running on the battery. When the dynamo was switched on there was a marked increase in the speed—about 40 or 50 revolutions, I should judge. All the conditions were the same as with

the battery. Will you kindly give an explanation of the above in your next issue?

(a) The only answer to this question seems to us to be that the spark was better located with the jump spark, and hence gave a quicker ignition. Usually there is not such a great deal of difference in the performance of an engine with the different systems, except that the average make and break, as used on stationary engines, will not stand a high speed, although the make and break system, when carefully designed, can be used at as high a speed as a jump spark. (b) In this case the dynamo evidently gave a lower spark and thus increased the speed of ignition. Changing the speed of ignition means that the flame gets a better start and advances more rapidly to the limits of the mixture. It has often been found that with a storage battery and dynamo combined used on an automobile the automobile would run faster with a dynamo.

* * *

(c) What are "heat units," and how are they figured out?

A heat unit is the quantity of heat required to raise a pound of water 1 deg. F., and is usually known as the British Thermal Unit. To obtain the number of heat units in a certain gas, the gas is made to heat a known quantity of water, and this weight, multiplied by the rise of tem-

perature in degrees F., is the number of B. T. U. given off by that amount of gas.

* * *

How do you form an emulsion of water and gas engine cylinder oil, emulsion to be permanent and used with a small pump?

Emulsion with oil is usually made with lime water by shaking up the oil with the lime water.

* * *

(a) What is the action of a jump-spark coil with and without an interrupter? (b) When is a coil without an interrupter used?

(a) A coil with an interrupter gives a series of sparks at the plug; that without an interrupter gives but one spark when contact is broken at the timer. (b) Non-vibrator coils are used almost exclusively for motor-cycles.

* * *

(a) Will vapor of kerosene mixed with hot air in equal quantities remain in gaseous state indefinitely? (b) What sized cube of gasoline (liquid state) for same size cylinder? (c) Why are gasoline engines self-starting not more successful or more used?

(a) No; air will not hold more than about 27 per cent at 68 deg. F. kerosene vapor. (b) 0.65 cubic inch vapor. .006 cubic inch liquid. (c) There are quite a number of so-called "self-starting" gaso-

line engines, many of which are very successful.

* * *

(a) What is the quickest and easiest way to remove asbestos and red lead from cylinder joints when the cylinder head or exhaust chamber has been taken off to be repacked?

(a) The only good way we know of is to use a scraper, being careful not to gouge the faces of the joints.

* * *

We have had a dispute about an engine sold to a party and would like you to tell us what horsepower the engine gives according to the following test: The machine was running at 370 r.p.m., and we attached a brake around a pulley 9½ inches diameter, the center of the shaft being 18¼ inches from where the brake beam pressed upon the scale. The weight registered by the scale was 17 lbs. 5 oz. The engine is 5x6 inches.

The size of the pulley has no effect upon the result when the brake is of the prony type. Taking the figures given, the result would be 1.87 H.P., which is too low for an engine of this size, as it should give about 3 B.H.P. There may be something amiss about the manner of making the brake test, and 17 lbs. 5 oz. may not be the net reading.

* * *

Will you please let me know which you consider the most economical method of ig-

nition, the jump-spark or the make-and-break? The question refers to the ignition of a stationary engine.

The jump-spark system is generally considered to be the most economical of current, as it can be operated with a shorter time of contact.

* * *

Is it practicable to use a gas engine instead of an 80 H. P. boiler and 60 H. P. engine to run a mill for operating a zinc mine, situated 6½ miles from Joplin, Mo.?

The answer to this question depends entirely upon the relative cost of fuels delivered at the zinc mill. A 60 H.P. engine will use 60 gallons of gasoline per day of 10 hours. The steam engine will require at least 1½ ton of coal for the same period. Suppose that gasoline will cost, delivered at the mill, 10c per gallon; then the cost of one day's fuel for a gasoline engine would be $6, and would equal coal at $4 per ton. Owing to several other considerations, such as the cost of labor for operating a steam plant in excess of that necessary to care for a gasoline engine, gasoline at 10c per gallon would be as cheap as coal at $3 per ton. Other advantages of the gasoline engine are that it will take up less room than a steam plant, and the engine can be started at any time upon a few minutes' notice. A gas producer system with a gas engine would probably be the best method.

In pumping water to a height of 20 feet with a centrifugal pump driven by a gas engine, will it make any difference in the power required if the pump is set at the top or at the bottom of the lift?

There would be no difference in the amount of power required, as the work done in either case is precisely the same. There is, however, an advantage in setting a centrifugal pump at the bottom of the lift when it is convenient to do so, as it makes easier to prime.

* * *

I have a two-cycle gasoline engine, 8½x 8, running at 325 r.p.m. I have been trying to calculate the exact amount of gasoline that should be injected into the cylinder at each stroke. The displacement of the piston is 453 cubic inches. According to an authority I have at hand, the ratio of the gasoline to air should be 1 to 9,060. This would require .05 cubic inch of gasoline per stroke, 16.25 cubic inches per minute and 975 cubic inches per hour, or about 4¼ gallons per hour. Comparing this latter figure with the consumption of gasoline as given by engine manufacturers, it appears to be several times too large. Can you point out where the mistake, if any, has been made?

The mistake lies with the "authority" from whom the constant was taken. Calculating the ratio from the average performance of a 10 H.P. four-cycle engine, the

ratio is approximately 1 to 25,060. A two-cycle engine of the dimensions given and running at the speed given above should develop at least 12 B.H.P. The average consumption of a two-cycle engine is one pint of gasoline per horsepower per hour. This would show that the consumption of gasoline given by the ratio stated in the inquiry would be nearly three times the actual amount.

* * *

(a) Gasoline is a liquid not commercially obtained in this part of the world (Singapore, Straits Settlement), and no information is to be had as to its composition, manufacture and other properties. What is the difference between it and benzoline, benzine, petrol and petroleum spirit?

(a) The term gasoline is a little indefinite when used by the trade. Technically, it is the heaviest of the three petroleum ethers, its chief chemical constituent being pentane, C_5H_{12}, and is one of the lightest hydrocarbons produced by the distillation of petroleum. What is known in this country as "stove gasoline" is technically known as the lightest of the three petroleum spirits which are distilled from crude petroleum after the petroleum ethers have been driven off and the temperature of the still increased. It is also technically known as "C naphtha," and as "benzine-naphtha." The following list may be helpful to you, and is given on the authority of Mr. Boverton

Redwood, and is quoted from his book on "Petroleum:"

	Specific Gravity.	Beaume's Hydrom.
Petroleum Ether—		
Cymogene	.69	108
Rhigolene	.625-.631	94-92
Gasoline	.635-.668	90-80
Petroleum Spirit		
C Naphtha	.716-.720	66-65
A Naphtha Benzine	.743-.747	59-58
Kerosene—		
American	.782-.800	49-45
Russian	.822-.830	40-38

Gasoline trade is commercially known as "stove gasoline," although much of it runs to 70 degrees, or even to 68 degrees B.

Benzine, as you will perceive from the above list, is "A naphtha," and is sometimes divided into two grades, the heavier being from 58 degrees to 59 degrees B., and the lighter from 62 degrees to 65 degrees B. Benzoline is the same as benzine.

Petrole is the French name for petroleum.

Petrol is the French name for a certain hydrocarbon, which is obtained near Hanover, but whose use does not enter into the gas engine industry.

The new Petroleum Exchange defines petroleum spirit as "naphtha shall be water-white and sweet and of gravity from 86 degrees to 73 degrees B. Petroleum spirit is already defined, its specific gravity being between .679 and .7. There seem to

be great objections to the use or handling of gasoline in foreign countries, which we in America do not appreciate, hence your difficulty in buying it.

Petrol, when used as an English word, usually signifies the same product of the distillation of petroleum as we in this country know as "benzine-naphtha" or "stove gasoline," being a lighter hydrocarbon than kerosene, of an average destiny of .68. It gives off an inflammable vapor at any temperature above the freezing point. Much of it is found in England, is lighter and more inflammable than the gasoline used for similar purposes in this country.

* * *

Kindly give what you consider good economy for the gas and the gasoline engine of today. For instance, what should be the fuel consumption of a gas or a gasoline engine of 16 H.P.?

Good economy in a gas engine depends upon the quality of the gas employed as a fuel. It is usually considered to be the consumption of 15 cubic feet of city gas per indicated horsepower hour. For a gasoline engine the consumption of gasoline should not be over .1 gallon per indicated horsepower per hour. For a 16 H.P. engine the gasoline consumption would be 1.6 gallon per hour and the gas consumption 240 cubic feet per hour. These figures may be increased as much as 20 per cent

when the delivered horsepower of the engine is taken as a basis.

* * *

(a) How does the cost, per delivered horsepower, of maintaining a gasoline engine compare with that of running an electric motor for propelling a small launch? (b) Please give me some idea of the difference in first cost.

(a) The gasoline engine will give a horsepower for a day of ten hours on 1¼ gallon of gasoline, making the cost for fuel per day with gasoline at 10c per gallon 12½c. For an electric motor of the same size the cost will be from 60c to $1 per horsepower day of ten hours. (b) A 1 H.P. electric launch will cost anywhere from $500 to $1,000, according to the maker. The same size gasoline launch, with a 2 H.P. engine will cost anywhere from $165 to $500.

* * *

Will you kindly give me the consumption of gas per horsepower in engines of standard make? If the capacity of the engine has any bearing on the subject, would say that we desire data on engines of 12 to 17 B.H.P. hour. Some engine makers give 16 cubic feet per B.H.P. hour, while others who claim to know say 25 feet. What we want is not engine makers' shop tests, but what the engines will do in actual service.

It should be noted that the fuel consumption of a gas engine depends as much

upon the quality of the gas itself as upon the engine. Again, a gas engine gives its best performance at full load, and this is what fuel consumption is generally based upon. We believe that engines of the size mentioned would use about 20 cubic feet of city gas per horsepower hour. Sixteen feet is good performance for such engines upon natural gas having a heat value of 1,000 B.T.U. per cubic foot.

TROUBLE INQUIRIES.

(a) I have a two-cycle engine of the Day type which gives me much trouble from explosions in the crank chamber. It frequently stops, seemingly without cause, giving a jolt to the engine as it does so. (a) Can you point out the trouble and suggest a remedy. (b) Would a check-valve between the crank chamber and the cylinder be of any service?

(a) When the explosion takes place in the crank chamber, increase the proportion of gasoline. The stopping without apparent cause is probably due to premature firing, and may be remedied by running the engine cooler. Perhaps there is a deposit of carbon on the piston or on the walls of the compression space. (b) This remedy is sometimes employed, but we do not think it is necessary.

* * *

Your answer to the previous question leads me to ask if you have ever seen a check valve used for the purpose mentioned. In my experience I have found it impossible to prevent these explosions by mechanical means, and I would be glad to learn that I am mistaken.

We know of several engines that have

employed this device, but do not know whether it has been found to be of any material advantage or not. It is certain that there are several successful engines that do not use a check valve between the crank chamber and the cylinder.

* * *

My engine frequently has the "thumps;" that is, the explosion is exceedingly loud and has a dead sound. What is the cause?

The trouble is due to misfires.

* * *

I have been making a vertical 5½x6 inch gas engine, but have not yet succeeded in getting it started. It is of the two-cycle type, and takes gasoline vapor from a carbureter situated 8 or 10 feet from the engine, by suction of the piston into the crank chamber. The carbureter consists of a tin box 18x20x9 inches, the last dimension being the height. This box is divided by means of partitions 2 inches wide, reaching nearly across the box. Hence the air must travel the full length of partition before it goes into the next one. All of these spaces are filled with excelsior, and the box will contain from two to three gallons of gasoline when the bottom is covered. (a) Does the air become sufficiently saturated with gasoline vapor when passing through this carbureter? There is an additional air inlet independent of the carbureter, with 1¼-inch pipe leading from the crank chamber to a poppet valve at the top edge of the

cylinder. (b) The spark is produced by means of a 10-inch coil, operated by two ordinary Leclanche cells. The electrodes are of steel. The spark is small at first and then gradually dies out. Can you suggest a remedy? (c) Can you favor me with the address of a manufacturer making platinum electrodes set in porcelain for use with Ruhmkorff coils?

(a) Your carbureter is large enough, and it is likely that you get too much gasoline and not enough air in the explosive mixture. (b) You are not using the proper electric cell for this purpose. Our advice is to get a 10-inch coil from a dealer in electrical supplies, and to operate your igniter from four special gas engine ignition cells. (c) Write to any electrical supply house.

* * *

I have a gas engine that I wish to use for driving an incandescent light dynamo. I have tried driving the dynamo with the engine, but I find that the light it gives is continually throbbing, giving a pulsation each time the engine has an explosion. How can I remedy this defect without purchasing a new engine?

The remedy is a simple one, and consists in using flywheels of sufficient weight to overcome this fluctuation. If the engine governs on the hit-and-miss principle it would reduce the required weight of the flywheel if the engine could be so altered

as to govern by reducing the quantity or the strength of the explosive mixture at every power stroke of the engine. The advice of an expert on these matters would be of great assistance to you and help you to avoid errors.

* * *

I have an engine which I purchased from a friend in the East, and find that it does not give the power claimed for it. I asked a friend of mine, who is a machinist, what he thought the matter was, and he laughingly remarked that it was "owing to the air." It appears to me that there might be a great deal of truth in this, although he evidently intended it for a joke. Am I right, and is the high altitude of this place (Leadville, Col.) to blame for the trouble?

Yes, you have hit the nail on the head. The altitude is the cause of your trouble, because the engine is not able to give such a high compression pressure as when at the sea level. The remedy is to add what is known as a "compression plate." The plate is fastened to the piston and gives an increased ratio of compression, and, consequently, a higher compression pressure. If you will send us the cylinder diameter, the stroke and the length of the compression space in your engine we will be able to give you the thickness of this plate.

* * *

In using a jump spark, I find that a wiping contact does not give a good spark in

the secondary of the induction coil. I have to use a contact of some force, and to tip the contacts with platinum. The coil has no vibrator. I use five cells. What is the reason that a vibrator does not give regular sparking? Would the use of a vibrator remedy the matter?

We believe it is better to employ a vibrator when using an induction coil. It should be remembered that a stronger spark is given when breaking the primary circuit than when the circuit is closed.

* * *

I have a hit-and-miss engine of 20 H.P. in my factory, and since I have put in a small dynamo for lighting the shop, I find that the engine does not give a sufficiently steady speed. I have several flywheel patterns which I could increase in weight. The engine is a 12x18, running 200 r.p.m., and my flywheel patterns are 5 feet and 6 feet, respectively. Which size would be the best to use, and what should be the weight of the rim to give good results?

Use the 6-foot wheel, and make the weight of the rims (two wheels being employed) 3,800 lbs. each. This amount will give a variation of about 2 per cent under the usual conditions of running, and is quite good for incandescent lighting. It is better, if possible, to employ a throttling governor whenever it can be applied without

considerable trouble and expense, as the flywheel can not take care of the fluctuations on light loads without it.

* * *

Will you kindly tell me how to start a gasoline carriage motor in cold weather? The engine employs 76 degrees gasoline pumped directly into the cylinders.

We would suggest that you try warming the cylinders before starting your engine. Should the engine use a water jacket, it could probably be accomplished by forcing hot water through the jacket, or perhaps by a supply of warm water to the water tank.

* * *

I have a 3½ H. P. two-cycle marine engine, using a gravity gasoline feed through a graduated tap into the air supply pipe. The air is heated by passing it through a jacket which surrounds the exhaust pipe. Suppose the engine is running with the propeller blades in position for going ahead; if the blades are reversed the engine runs faster for a few minutes, then slows down and stops. I can prevent it from stopping by increasing the gasoline feed for the time the blades are in the reverse position and then shutting the needle valve off to its former opening when the blades are returned to the go-ahead position. Will you kindly explain?

It is evident that when reversing the propeller it has not the same pitch as when in

the go-ahead position, and consequently the resistance is less. The fuel supply for a gasoline engine must always be increased in proportion for any increase of speed.

* * *

(a) I have a four-cycle gasoline engine, 5¾x5; r.p.m., 350; brake arm, 4 feet; pull on end of arm, 12 lbs. What horsepower does the engine develop? (b) I have used a carbureter and a gravity feed under valve seat, but neither gives satisfactory results. For instance, when the engine is running at 350 r.p.m. and a jerking load is thrown on, the speed is brought to 250, and the engine stops apparently because the mixture is too weak. When the governor speed is changed the mixture has to be changed to correspond. Is there any mixer I can put on which will overcome this trouble? (c) If the use of a pump for the gasoline feed would overcome this trouble, would you kindly give the dimensions of a suitable pump?

(a) 3.2 B.H.P. (b) It would be scarcely possible to point out the cause of your trouble without an examination of the engine. (c) A pump for a jet feed, suitable for an engine of this size would be very small, and we doubt if it would work successfully. The pump should have a variable stroke, which should be under the control of the governor. Its size should be 1-16 inch diameter, with a stroke that may be varied from ⅜ inch to no movement at

all. It will probably be found that a stroke of ⅛ inch will be ample. To make the feed pump operate successfully it should not be required to lift the fuel, but the fuel supply should be above the pump. The above dimensions are for a pump that has a stroke for each two revolutions of the engine.

* * *

How can I stop the noise of the exhaust in a 6 H.P. gas engine? The muffler does not give satisfaction, and I propose digging a pit so that I may invert a barrel in it and let the exhaust go from the muffler into the pit. Would this plan be a success?

A good plan to lessen the noise of the exhaust is to dig a pit for this size engine about five feet deep and four feet in diameter, and to lead the exhaust to the bottom of the pit. After the pipe is in place fill the pit with loose stones.

* * *

(a) Would you kindly advise me whether I should use a Ruhmkorff with a common push spark with a spring and a pin made of steel? (b) If I did, what would be the results? (c) Would it be necessary to use a circuit breaker, and how should the circuits be arranged for operation with a single coil? I find that the oil gets on the electrodes and they will not spark, and

I think that perhaps the use of the jump spark will avoid this trouble.

(a) The induction, or Ruhmkorff, coil is not suitable for use with the ordinary make-and-break spark. (b) The result would be that the secondary current would jump across at the wrong place and cause all kinds of annoyances. (c) We do not understand this question. If an ordinary spark coil is meant, it should be arranged in series with the break and the battery, or so that the current will have but one path, and a circuit-breaker would not be necessary.

* * *

I have a 4 H. P. engine in a 25-foot launch, and would like you to explain some peculiar phenomena which I have noted in connection with the engine. What causes the pounding of the engine with a peculiar metallic ring that increases in violence until it stops the engine? I find that it is most liable to occur when the air is moist—say about sunset. The engine will work all right during the day and then, with no other change in the conditions, will, about sunset, begin to pound. The trouble ceases upon reducing the flow of gasoline.

This trouble is caused by premature ignition of the charge; that is to say, the lead of the ignition is too great for the engine. Why this should occur when the air becomes cool and damp we are unable to say.

Why does gum accumulate upon the stationary electrode, and what may be done to prevent this trouble?

This trouble is due to excessive lubrication. Do not have the oil in the crank case any higher than is necessary for the end of the connecting rod to just dip in it about ½ inch. Pure oil is better for this purpose than oil and water.

* * *

I have an 8 H. P. gasoline engine that makes an upnleasant thump or jar each time it explodes. It runs all right and seems to develop full power, only this thump is unpleasant. Do all gas engines do this, or do they run smoothly, like a steam engine? (b) If so, why does mine do this? The spark occurs 3-16 of an inch before the piston reaches the dead center, so that it can not be caused by too much lead.

(a) All gasoline engines do not work this way, and they should, as you suggest, run as smoothly as a steam engine. (b) This question is hard to answer without a personal inspection of the engine itself, but the following suggestions may be of assistance to you: If you have followed the instructions given on page 39 of the Handbook, try running the engine with cooler air in case the air is heated before passing into the engine. Take off the cylinder head and examine the inside carefully for deposits of carbon, and if there is a projection at any point, cut it down, if it is pos-

sible to do so without damaging the engine. It is quite probable that you are getting premature ignition from some cause or other, which you can discover if, after the engine has been running a while, it will continue to do so after cutting off the igniter current. It might be well also to examine the water jacket, and see that it is perfectly free from sediment, as the trouble may be caused from imperfect cooling of the cylinder.

* * *

I have a two-cylinder, four-cycle engine with suction admission valves. There is a constant outward pressure of vapor through the air regulator. What is the cause and what is the remedy?

The trouble is caused apparently by leaky valves. They should be carefully ground until a good joint is obtained, and it should be seen to that the springs bring the valves firmly and squarely to their seats. Examine the bearings for the valve stems, as they may be worn and allow the valve stems to run out of line and tilt the valve, making it seat improperly.

* * *

What is the cause of the excessive sparking at the outside contacts on gas engines? I have noticed this to occur particularly where the contact is made by rubbing or wiping.

The cause of the sparking is the high tension of the current at the moment of the

break, caused by the self-induction of the spark coil, which is placed in the circuit for the purpose of making a large spark in the engine cylinder. This spark at the outside contact may be avoided by so setting the switch that it will break the circuit on the outside, while the circuit is open inside the engine.

* * *

(a) I have a gasoline automobile with an engine 4½-inch bore by 6-inch stroke, which is air cooled. This engine gives very little trouble until hot weather commences, and then it will stop for no apparent reason. Will you kindly point out the cause of the trouble? (b) If it is caused by overheating, would water-jacketing help matters any?

(a and b) The surmise is right. The trouble is due to overheating, and would be helped by the use of a water jacket.

* * *

(a) We have a 4x5 inch, four-cycle automobile engine, which should develop 3 H.P. at 700 r.p.m. The exhaust valve and the inlet valve are each one inch diameter. The cylinder head and the exhaust chamber are not water jacketed, nor have they ribs. The engine runs well when cool, but soon loses a portion of its power. When allowed to stop, and it is started again while it is hot, it shows premature ignition. The inside of the head is concave, with an opening at one side 1 inch diameter by 2 inches

long, to the valve chamber. We have opened the exhaust so that it has now a 1¼-inch pipe leading away from the muffler, but this has not helped matters. The ignition is by jump spark, which is set to fire normally at the back center when the engine is started. We can detect two distinct explosions, one of which seems to come from the heated surface and the other from the spark, when endeavoring to start the engine is an overheated condition. Would water jacketing cure this trouble, or must we put on a new head? (b) Would you advise putting on a new piston, cylinder and valve chamber, all water jacketed, but making the bore 5 inches, with the same stroke as before? (c) The engine has three fly wheels 13 inches diameter, with a rim 2x1½ inches, two of these flywheels being connected by a fly wheel between them and the other being placed outside the crank case. The main shaft is 1¼ inch diameter and the connecting rod 10x1¼x⅝ inches diameter, both of steel. We can not ascertain the size of the piston pin, but could bore the rod to suit. Do you consider it safe to put in a 5-inch piston? We could then enlarge the exhaust passages to 2¼ inches. (d) Would this result in the engine running any faster, and, if so, how much?

(a) We believe that water jacketing the compression space and about one-half of the stroke would obviate this trouble. If

practicable, it is advisable to jacket both the head and the valve box, or at least to cool them by means of fins. (b and c) We should not advise putting in a new piston of the size you mention without increasing the size of both the connecting rod and the crank shaft. It would probably be necessary to use heavier fly wheels with a larger piston. (d) Increasing the sizes of the passages will usually assist in obtaining a higher speed, but it should be remembered that within the limits of the time required for full inflammation after ignition, the speed is also a factor of the load.

* * *

(a) I am repairing a gas engine which has a lime scale nearly or quite 1-16-inch thick in the water space. Is there any solution that will dissolve it? (b) I understand that there is a compound which may be placed in the water to prevent this scale. If so, will you kindly inform me what it is and where it may be obtained? (c) I presume that this compound may be employed only where a tank is used for the cooling system.

(a) The solvent will depend entirely upon what form the lime is in. You might try filling the jacket with kerosene and allowing it to remain in the jacket for a day or two, or the use of a solution of carbonate of soda may loosen it up. If the lime is in the form of a bicarbonate, hot water or a solution of caustic soda may be re-

quired to remove it. (b) Any substance that will act as a solvent will also act as a preventative. (c) We do not believe that a scale preventative would be of any service, except in large quantities, unless a tank were employed. In case a tank is employed we would suggest the use of rain water as the much better way out of the difficulty.

* * *

In an engine governing by throttling the mixture is there a danger of a small charge failing to ignite from too low compression, and is not the following charge likely to be stronger than necessary?

With ordinary fuels there is very little danger of such an occurrence. A misfire is more likely to cause an explosion in the exhaust passages. Weak mixtures usually cause slow inflammation.

* * *

I am operating a gasoline launch and find that when I make a sudden turn the engine will stop. Can you tell me the cause and the remedy?

While we have heard of this trouble, we have never experienced it, and therefore can only conjecture the cause, which we believe to be the shutting off of the gasoline. A correspondent states that cause of this sudden stopping is simply the overloading of engine, as it takes a great deal more power to push a boat around in a circle than in a s raight line. The only way to overcome it is to make long turns or to slack

down when turning. He has a very powerful engine in his boat, but most always has to turn rudder a little when making a sharp turn in order to keep engine from stopping or choking down.

* * *

I have a four-cycle engine with a hit-or-miss governor, which controls the speed by holding the exhaust valve open during the idle stroke. The engine is fitted to operate on either gas or gasoline, and the inlet valve is operated by the suction of the piston. The engine gives little or no trouble when operated with gas, but when we change to gasoline, it cuts up various capers, principal among which are great fluctuations of speed on light loads. The trouble seems to be that engine will fail to secure an explosion for one or more cycles after the governor has let go of the exhaust valve, and this failure is frequently followed by explosions in the muffler. Can you suggest the cause and the remedy?

The cause of the trouble is, we believe, the fact that the inlet valve opens slightly during the suction strokes, and when the engine misses several impulses in succession, gasoline is drawn into the cylinder and the next charge drawn is made too rich to ignite. The remedy is either to tighten up the inlet spring so that it will not open, to place a locking mechanism on the stem of the inlet valve that is under control of the governor or to place a relief

valve in the exhaust pipe near the engine. The trouble usually occurs with a long exhaust pipe, and is due to the inertia of the column of gas, producing a slight vacuum in the cylinder, which opens the inlet. Placing a valve with a light spring in the exhaust pipe will allow air to enter the pipe from near the engine and prevent the formation of this vacuum. We believe that this is probably the best solution of your trouble.

* * *

(a) Is there any way in which an asbestos gasket may be treated in order to reduce its liability to blow through? (b) Is there not some way in which a joint with an asbestos gasket may be broken without tearing the gasket to pieces and necessitating its renewal? (c) Is there any material that may be used instead of asbestos?

(a) Saturate the gasket with either oil or silicate of soda. (b) By saturating the gasket with silicate of soda and chalking one face of the joint the joint will break and leave the gasket on the side that is not chalked. Thus in packing the cylinder head the head is chalked, and the gasket will then stick to the end of the cylinder when the joint is broken. The head should be screwed tightly into place, while the gasket is still wet, and left in position for at least twelve hours while it hardens. (c) None that we are aware of.

I am in difficulties with the oiling of crank-pins on my double 5x5 horizontal gasoline motor, opposed cylinder type, cranks at 180 degrees, enclosed crank-case, which I intend using in a special automobile. The motor is of a tried successful design and the workmanship and material are first class in every respect. There is nothing to be desired in cylinder boring and fitting of pistons and rings. The compression is perfect (compression space, 30 per cent of piston displacement). There are three rings, ½ inch wide each, at head end of piston; none on the crank end. There is no chance for oiling crank-pins through the shaft, as one end of the same runs necessarily too close to the lay shaft of the transmission gearing, while the other end must be free to receive the starting crank; therefore there are but two methods available for oiling these parts—one by cutting away the closed crank case at the top sufficiently to provide clearance for oilers to be carried on crank-pin ends of connecting rods, and the other by carrying oil in the crank case. The first method I do not like, as it involves weakening the present crank case or the making of a new crank case; and in the other instance there is the objectionable feature of carrying oilers on a very high speed short-throw crank. On running the motor by belt with gas-engine oil in the crank case I find that the oil works past the piston rings into the com-

bustion chamber freely, whether the crank case is run tightly closed, with a vent, or with a check valve, opening inward. Just enough oil was used so that connecting-rod ends dipped ½ inch, and the motor was run at only 350 revolutions. All results indicate that a mixture would be hopelessly spoiled and ignition (jump spark) practically defeated by attempting to carry oil in the crank case, but I have not yet run the motor by its own power under these conditions. To prevent crank case oil from working back into the combustion chamber I have thought of making new pistons, with an additional ring at the crank case end; I have also thought of putting a brass plate over the open end of the cylinder, with a slot in same just wide enough for the connecting rod to play in, the plate tending to keep the oil from splashing into the cylinder. I have also thought of adopting a suggestion received from the description of a gasoline vehicle, namely, to run a groove around the cylinder bore one-half way down from the top, with either terminating in horizontal grooves, these grooves to be fed by a cylinder oiler; then to use a hollow wristpin to take up oil from the horizontal grooves for the lubrication of the wristpin and passing the oil along to the crank pin through a hole drilled lengthwise through the connecting rod or by means of a small pipe carried on the rod.

It would appear that the difficulties you

expect to encounter are more imaginary than real, as horizontal engines of this kind are run successfully with crank-case oiling. It would seem, however, that you use too much oil in your crank case. Dipping ½ inch into the oil is too much for this small engine. Lower the height of the oil until the rod just barely touches it and then feed the oil so as to keep it at about this same amount. If you should experience excessive oiling with this method, use a hollow connecting rod, with a hole not over one-fifth the diameter of the rod. This hollow rod should, of course, communicate with the piston pin and the crank pin through wicking, and by using a hollow piston it may be possible to oil the piston from the rod. This hole in the rod will carry sufficient oil for quite a long run.

* * *

I have a 3⅜x4-inch stroke, 4-cycle horizontal engine. When I got her six months ago she ran fine, at least I thought so; she pulled all I had for her—a small wood lathe and a small circular saw about five inches in diameter, and as I ran her only in the evenings about two hours and on Sunday three hours at a time, she ran all right for about four months at this rate of running. Then she took a notion to balk. She would run for about ten minutes with plenty of misfires, so I consulted an expert, and he advised me to get an igniting dynamo, which I purchased. Now, after that I

thought the trouble was all over. We tried her for about fifty minutes, and she seemed to run all right that night, empty, not thinking of putting on a load and see how she would act. I left her for a week, thinking everything was all right. The next time I wanted to do some work on the rip-saw I started her up all right, but when I commenced to saw she started to slow down. I stopped until she picked up again and then tried her again, meeting with the same result. After concluding I could do nothing but consult another expert, so he examined her all over and concluded she had not enough compression, so we stripped her and calipered the cylinder and found it worn out of round a scant 1-16 inch. So I had her rebored and put in a new piston and new rings, and they showed a fine bearing, and the piston was a nice fit. So I put her together again and, as it was late to try her any length of time, we ran her for a few minutes and concluded she was all right. We left her until the following Sunday, as I was working overtime and could not try her in the evenings, or I felt at least as though I had done enough all day without bothering with her; so I let her go until Sunday, and after reading so much about gasoline engines, every one states as though there are only three vital points on a gasoline engine—a good spark at the right time, perfect compression and a perfect mixture. So I concluded we had

overcome at least two of the vital points, leaving only the mixture to bother us much, so I proceeded to try her Sunday. I thought I would run her for a few hours first and watch her behavior before starting to do any work. She ran about ten minutes fairly up to her speed, as her governor took care of that; then she commenced her funny capers again, as though she was missing fire, back-firing, premature explosions, and it sounded in the cylinder, an awful thumping thud noise at every explosion, and at the same time slowing down to about half her speed, and then gradually slowing down and finally stopping, so there was more trouble again. So I tried to start her again. She is ever ready to start on the first turn of the wheel and give about two explosions, then stop again. Letting her alone for an hour, I tried her again; she ran exactly as before for about twenty minutes, and slowed down and finally stopped. As the engine had about from 52 to 53 per cent compression space, I concluded to reduce the space to about 30 per cent the displacement of the piston, as I saw in your answer to an inquiry that from 30 to 40 per cent was the per cent used for a 4-cycle engine by most M. E. of gas engines. So I added a piece to the piston, changing the compression space to about 31 per cent or 32 per cent, and connected a steam gauge to the combustion chamber to see what pressure per square inch the gauge regis-

tered. By turning the flywheel by hand, as slow as possible, it registered 35 pounds per square inch, and by turning the flywheel as fast as possible by hand the gauge showed a pressure of 55 pounds. I could not say how true the gauge is, as it shows or registers 3 pounds per square inch where it should read 0. After examining all valves to see if they were tight, and thinking the pressure afforded a good compression, I started her up again. She ran for about twenty minutes just the same as before the change, then stopped again, but while she was running. I imagined there were some premature explosions taking place, so to see if this was from carbon deposits, or highly-heated projections or screws on piston head, I threw out the switch and, to my surprise, I seemed to hear three distinct explosions within the cylinder with the switch open, so, throwing on the switch again, I tried this method several times, but never noticed any explosions when the switch was off again. It is a puzzle to me what is the trouble with her. She does not seem to develop half the power she did when I first got her. The engine is a water-cooled jacket, exhaust valve works by a cam, the inlet valve works by the suction of the piston, all in the cylinder head that is not water-jacketed. Besides, the hammer-break spark is in the same head between both inlet and exhaust valves. The contact is broken by the action of the pis-

ton striking the point, and thus breaking the contact and causing her to spark. The fuel supply is controlled by a mixing valve. She ran once under the same conditions as stated before. Now, what I want is, if you please, give me your advice.

This is certainly quite a long tale of woe, and the editor assures the questioner that he has read it through several times without coming to any other conclusion than the feeling that he would like to get hold of that engine himself and see what really is the matter with it. In spite of this long explanation, it is a difficult matter to tell just what is the matter without being on the ground. The editor will, however, offer some suggestions, and would say that the thumping may be due to a tight piston, the use of either warm or hot inlet air, the exhaust closing too late or the igniter set too early. Judging from the description, it is more likely to be either a late closing exhaust valve or overheated air. Examine the exhaust valve and see that it closes just as the piston reaches the end of the exhaust stroke. Don't heat your inlet air. Also, look for a short circuit or an open circuit in your electric system. One thing that might cause this trouble is a loose wire that will sometimes be in contact and again will be shaken out of contact. This will usually be shown by the engine running by fits and starts. It is certainly to be regretted that the parties from whom you purchased this

engine are out of business, as they are really the ones to help you out of your trouble. However, if you can secure, not a so-called expert, as you seem to have had before, but a man who really understands gas engines, he can probably locate the trouble in a very short time. If there is a gas engine factory in your city, try to get hold of a man from the factory who sets up and tests the engines, and we feel quite sure that he will be able to help you out of your trouble.

* * *

(a) I am having trouble with a gas engine oiler, and write to you to know if you can put me right. The engine is a marine engine of 4½ H.P., and the oiler is a sight-feed one. The oiler will sometimes work all right for half an hour or so and then it will be observed that the sight-feed part of the glass is filling up, and when this becomes full no more oil will go in the engine. I have cleaned out the oiler and also the pipe leading to the engine on the end of which the oiler is screwed. The oil does not boil, but remains perfectly tranquil and clear. There is a similar engine working well, and I have tried the oiler from it, and it acts in the same way on this engine in question. Would a check valve in the oil pipe help matters? I am thoroughly at a loss to account for this behavior, as sometimes the oiler will work all right and then, for no apparent reason, will fill up and re-

fuse to feed the engine. The oil is of good quality and is being used in the other engine mentioned. There is no leakage of pressure from the oiler. If you can help me in this difficulty I shall be much obliged, and for that reason I have written fully. (b) In governing a two-cycle engine, used for stationary purposes, is it good practice to throttle the mixture between the vaporizer and the check valve on the crank chamber? Is there a likelihood of causing missfiring or crank-chamber explosions by decreasing the quantity of the mixture in this way?

(a) This case is similar to the previous one, in that we could probably tell better what was the matter by being on the ground. However, we might offer some suggestions as in the answer to the previous inquiry. In some lubricators which the writer has used there is a little ball valve in that portion of the lubricator which has the pipe thread. Continuous pressure agains this ball would stop the flow of oil into the engine, as it would hold the ball against the seat. This valve acts in the same way as a check valve in the oil pipe. If there is not a pressure-equalizing tube on your oiler, this would probably explain the cause of your trouble It is a good plan in all these cases to write direct to the manufacturers and tell them what kind of an oiler you have, and they will be better able to answer it, probably, than we could. (b) Always throttle a two-

cycle engine either between the vaporizer and the crank chamber or in the passage from the crank chamber to the cylinder.

* * *

Now that our gas supply has failed us, we are using gasoline instead, and are troubled by the engine back-firing, and think it due to insufficient water jacket. (a) Will you please name other possible causes for premature ignition and suggest the proper remedies?

(a) Back-firing may be due to your using gasoline rather than natural gas without changing your compression, or it may be due to what is known as "hot-bolt ignition," where some projecting "stub or other part becomes heated to incandescence;" or it may be due, as you suggest, to inefficient jacket water, either in the amount of cylinder wall which is jacketed or to the inefficiency of the cylinder wall as a heat conductor, due to the jacket water space being more or less coated or filled up with lime and magnesian salts. The running of the engine might be improved by increasing the clearance space, and so get a lower temperature of compression. If the engine has not sufficient jacket water space the quickest and cheapest remedy is to sell it or scrap it, unless the makers can provide you with a better design of cylinder and cylinder head. If the jacket water space is filled up with lime it should be removed. Possibly your

vaporizer is not efficient and is using more gasoline and less air than is necessary.

* * *

I am operating an 18-foot launch with a 4x5, two-cycle engine, using a generator valve supplied with gasoline from a tank in the bow. Why is it that when I leave the engine to go to the bow of the boat it will start missing explosions, and when I go back to it again it will be running all right by the time I reach it? I have asked several gas-engine experts about the matter and none of them seems able to offer an explanation.

The trouble is caused by changing the head of gasoline when you walk to the bow of the boat, as the boat being small the bow will be depressed by the change in the center of gravity. If you will stay by the engine and let somebody walk back and forth in the boat you will find that when he is near the engine you will need a smaller opening in the needle valve than when the weight is changed toward the bow. The remedy is to give the needle valve a little wider opening just before you start for the bow, and you will find the engine will work all right.

* * *

I have a gas engine which has been converted to use gasoline. I find the time of ignition must be changed to come later, as I get premature ignitions and have broken the crank shaft. I use a tube igniter, and

wish to know whether I should use a sorter or a longer tube to fire later, or should I use a different diameter tube.

Use a shorter tube for later ignition.

* * *

I have had a little trouble with a "balanced" four-cycle gas engine, having two pistons in one cylinder. The cylinder is 2½ inches in diameter by 2 inches stroke on each end, and has about 25 pounds compression. (a) Has such an engine twice as much power as an engine of the same size with one piston? (b) How much power should this engine give when running at 1,000 r.p.m.?

(a) This engine should have as much power as a single piston engine with six-inch stroke. (b) Assuming that the engine would have, when properly constructed, a compression pressure of about 60 pounds per square inch, or even greater, the limit being about 100 pounds for gasoline at 1,000 r.p.m., you should secure from 1½ to 2 H.P.

* * *

I have a 20 H.P. gas engine running on natural gas which is subject to peculiar streaks, and, while it runs exceedingly well at times, yet it has a habit of suddenly slowing down and stopping altogether. Of course, this is very annoying where a constant power is necessary, especially as the engine runs a dynamo among other machinery, the dynamo being used for nickel-

plating. A representative of the manufacturer has been here twice, and each time the engine was doing very nicely and he was unable to find any trouble with it. Perhaps, with your wide experience in helping people out of trouble of this kind, you might be able to point out the cause of this queer performance.

The most probable cause of your trouble is a variation in the line pressure of your gas main. This is of quite frequent occurrence in natural gas regions. It is quite probable that the branch pipe from the main to your engine is too small, or possibly the main itself is too small. In case it is not practical to increase the pipes, an alternative would be the installation of a gasometer of sufficient size to tide over a time of insufficient pressure. Quite often there will be sufficient gas to run the engine if the gas cock were given a larger opening to make up for the decrease in pressure. When the gas cock is set for a certain pressure any appreciable change in this pressure would vary the mixture so that it would not ignite. The best way to overcome this trouble is to install a pressure regulator that would bring the gas pressure at the engine down to practically that of the atmosphere. This regulator is generally installed in addition to the regulator customarily employed to bring the pressure down to about 1 pound or less. This regulator will not only overcome the trouble you refer to, but also assist the gov-

ernor of the engine in maintaining a constant speed.

* * *

I have a 4 H.P. marine, jump spark engine which has been giving me trouble. The vibrator will stick and the engine will stop, but by merely touching the vibrator with the finger it will start again. I have adjusted it in every conceivable manner, but it will not work correctly. (a) Please tell me the cause of this trouble and how to regulate the vibrator. (b) What makes the charge fire in the exhaust pipe every little while, and how can I prevent it?

(a) Your trouble is evidently due to a weak battery. A good way to adjust the vibrator is to screw up the spring until the small armature is drawn quite close to the end of the iron core, say within about 1-32 inch before it breaks the circuit. Make sure that the adjustment is such that the armature will not strike the core. The best way to adjust the vibrator is while it is in operation, and the adjustment should be such that it will start instantly when the circuit is closed, without assistance from the finger. (b) Explosions in the crank case of a two-cycle engine are due either to a weak mixture or too late ignition. Explosions in the exhaust pipe are due to the presence of a charge that has passed through the cylinder by missfires, although they are occasionally caused by too rich a mixture.

(a) Is there a better way to start a gasoline launch engine in cold weather than by continued cranking and warming the cylinders by the imperfect explosions? The engine is enclosed by curtains only and has a plain vaporizer and no simple method of heating the cylinder. The ignition is electric and 76 degree gasoline is used. (b) At how low a temperature should such an engine start?

(a) The best way to start the engine in cold weather is to fill the water jacket with boiling water and allow this to warm the cylinder. We should suggest a small oil stove and a tin can. (b) We have started engines with the temperature as low as 7 degrees below zero.

* * *

I have a small marine engine that is giving me all kinds of trouble. It picks up the gasoline by passing the air through a long hose. In pleasant weather this arrangement works very well, but as soon as it begins to rain or when the weather is damp, the engine explodes in the crank case continually. I have had a hard time getting home on several occasions, and have even had to lie to until a storm was over. Will you kindly explain the cause of this trouble and suggest a remedy?

The cause of your trouble is that the air when saturated with water vapor will not take up the vapor of gasoline in sufficient quantity to make a proper explosive mix-

ture. The explosions in the crank case of a two-cycle engine invariably indicate a mixture poor in gasoline. Your remedy is to abandon the carbureter entirely and lead the gasoline from the tank to your engine by a 3/8-inch lead pipe, and use a vaporizer, consisting of a spring check with a pin hole in the valve seat. You will find that you probably have to turn on a little more gasoline during a heavy shower, or after the sun goes down and the air becomes heavily charged with moisture, but you need never get left out on the water on account of a moist atmosphere.

* * *

I have a vaporizer, called by its makers a carbureter, which, although it works very well, seems to prevent the engine from giving its full power. It is of the spring check-valve type, and I have found that by holding down the valve the engine will run considerably faster and develop more power. Is there any way that I can improve this vaporizer so it will develop more power without having to hold the valve down?

It is quite evident, for one thing, that the spring is not too stiff, and for another that the valve is too heavy. Remove the valve and cut it out opposite its face, making it as light as possible without making it too thin, and then use a light German-silver spring that will hold the valve to its seat and let it drop to its full

stroke upon the application of a weight of from eight to ten ounces.

* * *

Will you kindly tell me what is the matter with my engine? It gave me not the slightest trouble for the first six months that I ran it, doing duty ten hours a day and never refusing to carry its full load. Now it runs by fits and starts, sometimes taking about a dozen impulses all right and then slowing down, to pick up again when it reaches in the neighborhood of forty turns per minute. I have tried a new battery without helping matters any, and no one about here seems able to help me out of the trouble. What do you think is the matter?

The cause of your trouble is evidently a case of vibrating connections or a broken wire somewhere inside the insulation. The peculiar behavior is due to the fact that when the engine is not going at a very high speed the circuit is complete, apart and the igniter circuit is broken. tion sets in the loose connection is shaken apart and the igniter circuit is broken Go over the wiring carefully, preferably with a bell and battery, and we are quite sure you can easily locate the trouble.

* * *

What is the cause and what remedy would you suggest for a thick slime which I have been finding in the gasoline that I am using? It has somewhat the appear-

ance of oil. I have heard of a number of persons who have been troubled with this. It is very annoying, as if any of it gets into the vaporizer the engine stops.

A heavy deposit from the fuel is usually due to evaporation of a poor quality of gasoline. Evaporation carries off the lighter portion, and leaves the heavy oils, which are useless for operating the engine. The remedy would be to get good gasoline of at least 72 degrees by hydrometer. Another good plan would be to take the gasoline from a point about ½ inch above the bottom of the tank which should be cleaned out occasionally in order to remove this residue.

* * *

Will you kindly tell us of a good way to entirely overcome the back firing in a two-cycle engine. We know that a rich mixture should reduce it very much, but this seems a waste of fuel, and soots up the cylinder.

To answer this question it is best to explain the reason for crank case explosions. This is invariably due to lag of flame in the cylinder; or, in other words, flames left behind and igniting the incoming fresh mixture. A weak mixture ignites slowly and causes the flame to lag. Late ignition will do the same thing with a fairly rich mixture. The trouble may be overcome by increasing the lead of the ignition and by increasing the distance in

the direction of the piston stroke, by which the exhaust port begins to open. Either make your exhaust port open earlier or your outlet port later, and see that your igniter has sufficient lead; this will eventually overcome the trouble. One of the most efficient cures for the crank case explosions is an ignition governor, which advances the spark lead as the speed of the engine increases.

* * *

(a) I have a two-cycle two-cylinder marine engine rated at 3 H. P. by the manufacturers. It is 3¼ inches by 3 inches, and runs at 620 r. p. m. with the propeller now in use. The cylinder head as well as the sides are water-jacketed, and the compression space on top of the cylinder is ¾ inch. Is not this compression space longer than it should be, and if so, what clearance would you recommend? (b) If the compression space is too large, would it help matters, or increase the revolutions, if metal plates were bolted on the cylinder heads? (c) From the cylinder dimensions and the revolutions, what horsepower would you expect the engine to be developing?

(a) This is the compression space usually given for two-cycle engines. (b) If your connecting-rod is a stout one, you might experiment by adding first a plate ⅛ inch thick, and then another ¼ inch

thick on the inside of the cylinder. If this does not give you pre-ignitions, it would probably increase the power of the engine and its speed accordingly. (c) For the ordinary marine type of engine, drawing gasoline into the crank-case through a check valve, we believe that the engine is not developing over 3 B. H. P.

* * *

(a) Should the spark plug of a 1 H.P. engine extend down from the cylinder, cutting into he cylinder itself? I am having trouble with this engine, and note that the plug is up in a hole in the cylinder head nearly three inches above the opening.

We consider the best effect is by allowing the points to project into the cylinder, or to have them not over ¼ inch back in the recess. Placing a plug in a pocket is sometimes done to prevent sooting, but it retards the ignition and makes it too late for high speed.

* * *

I have a 25 H. P. gas engine which exhausts into an ordinary cast iron box, and thence to the air. As our factory is in close proximity to a residential district we have frequent complaints about the noise of the engine, which I must admit is considerable. Will you kindly recommend some cheap and efficient form of mufflers, so that I can get rid of this trou-

ble and the complaints of our neighbors?

We suggest digging a pit five or six feet deep and about three feet diameter in the ground just outside the engine room and convenient to the exhaust pipe. Leave the cast iron muffler as it is, and a pipe from it down within six inches of the bottom of the pit. The pit should have, if possible, a drain at the bottom to carry off any water which may collect. Now, fill the pit to within about a foot of the top with cobblestones or old bricks thrown in loosely. Place over the center a cast iron plate or a flat stone about twelve inches diameter. This is assuming that you can use a pressure circulation with the cooling water running to waste. Fill the pit to within about four inches of the top, and cover it with a flat stone through which should be two holes, one in the center for the water, and leading from the engine and the other for the exhaust pipe near the edge of the pit. Run the water into the top of the pit so it will strike the plate or small stone and spread over the bricks and loose stones in the pit. Now start your engine, and you will find there will be very little noise. If circumstances render such a scheme out of the question, the nuisance may be ameliorated to a certain extent by digging a shallow pit and making provision for keeping it full of water, say a hole about three feet diameter, tapering down to a

point, and about two feet deep. Conduct the outlet water to this pit, and keep it full, and leave the end of the exhaust pipe about three inches blow the surface of the water. You will find that this will not be quite as good as the pit full of stones, but it is cheaper and quite effective. If the exhaust is so powerful as to blow the water out of the pit it will be necessary to deepen it so the sides are high enough above the surface of the water to allow it to flow back.

* * *

I have been running a well-known make of portable gas engine for about four years, and last summer decided to try kerosene, purchasing from the manufacturer what they called their kerosene attachment, but it does not work very well with the electric igniter, which is of the make-and-break type. The engine will run all right for a few moments after I change to kerosene and while there is a little gasoline mixed with the kerosene. Then it will commence to miss an explosion, then two, then three, and so on. It may run twenty minutes or half an hour, then the engine stops. After the engine stops it is generally found that the inside of it is well smoked. On examining the points they will be discovered to be completely covered with soot, and after cleaning them the engine will run about the same length of time and stop.

I am using a small dynamo for generating current for the igniter. The engine works all right on gasoline, but that is very hard to get here. In working the kerosene attachment the fuel is warmed by passing through the exhaust muffler. Any information you can give will be greatly appreciated.

We would say, in the first place, that you do not get your engine sufficiently warmed up before you change from gasoline to kerosene. To run an engine of this type successfully on kerosene it is necessary to heat the cylinder as nearly to the temperature of boiling water as possible. We believe that if you will keep your jacket water at a temperature of over 200 deg. you will have no further trouble. You will find your engine will work better with kerosene oil on a heavy load than when running light.

* * *

I have a four-cylinder, four-cycle engine with a make-and-break igniter and spark shifter. I wish to take the igniter current from a 110-volt circuit, and wish to know which is the best resistance to use and what voltage and amperage would be best, and not destructive to the platinum point. I have tried wiring from 110-voltage circuit according to the diagram in Mr. Stritmatter's book, but it is not very satisfactory. When the engine

runs slow under load it is all right, but when attempting to speed up ignition fails. When running with no load she will rack herself to pieces on the 110-volt-circuit-resistance ignition even with the spark retarded and mixture throttled. I have a magneto which will ignite the charge excepting at the slowest speed and the engine will not race as running when running under no load and on the 110-volt circuit. I have tried all the combinations of lamps, and have always had them in multiple the same as in the diagram. Is there any difference in economy of current between wound resistance and lamp resistance? (b) Can you give me any information upon the use of graphite for an engine cylinder? (c) Will kerosene fed into a gasoline engine while running do any good in cleaning the engine from carbon, or will it make more?

Your trouble seems to be with a method of wiring by the diagram. You must be getting current around the lamps. If you had four 16 candle power lamps in circuit with the igniter the current at the igniter points should not be over two amperes, and as much as six amperes has been used without harm to the igniter points. Unscrew the lamps from their sockets and see if there is still current passing to the igniter, and look for the point at which it gets through. We know no reason for not running a mag-

neto after the engine is started and using the lighting circuit to start with. There is no difference in a lamp resistance and a metallic resistance, but one that is in form of a coil, unless non-inductive, will act in the same way as a spark coil. (b) Unfortunately, we are not informed on the use of graphite in a gas engine cylinder excepting by hearsay. We understand, however, that it has been used with considerable success. (c) Kerosene fed into an engine while running will, if anything, make it worse in depositing carbon. However, engines that are fitted with some forms of vaporizers can be run on kerosene, sometimes to better advantage than on gasoline.

* * *

Will you kindly explain to me what is the difference between the following two engines? They are both of well-known make, same bore and same stroke, and both develop the same horsepower at the brake. One make pulls the heaviest load when the igniter has a load of one-ninth revolution, and the other engine will barely run with the igniter down that far, but pulls the most with the igniter set at dead center. The speed of both engines is the same, but one is governed by the gasoline and the other by holding the exhause valve open.

It would be rather difficult to tell what is the reason for this difference without

personally examining the engine. A lead of 40 degrees at 350 revolutions is excessive for an engine running at full impulse every revolution. It is probably due to either a fault in observation of the time of the spark or the location of the spark in a recess. There is certainly some mistake in the observation of an engine which does its best with the igniter set at dead center. We have never found an engine that would give its full power without a lead of at least 15 degrees at the specified speed.

* * *

As soon as I run the exhaust water at boiling point there issues an appreciable quantity of drops of water around the top of the cylinder head. Is this not indicative of a loss in compression at the cylinder heads? How can I correct this, as the screws seem well seated?

We would suggest screwing up the cylinder head studs while the engine is warm.

* * *

Please inform me which is best to use in a carbureter, cold or warm air? I have a carbureter for 12 H. P. 1¼-inch outlet. After a half hour's use large drops of water form on the outside of the side of the pipe that leads the mixture to the two cylinders. I am now using cold air.

The colder the air the greater the weight of air you can get into the cylinder, and in consequence the greater power there will be the impulse. With the modern form of vaporizer it is usually not necessary to use warm air, but when very damp, slightly warmed air will help vaporize the gasoline. The water which deposits on the outside of the vaporizer is due to the refrigerating effect which comes from the vaporizing of the gasoline.

* * *

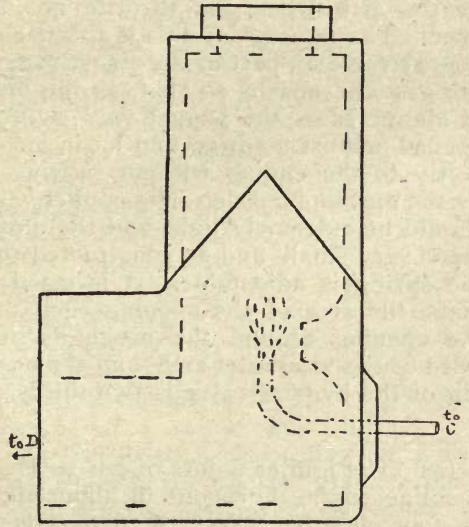
I have a small engine in a launch which will run nicely for twenty minutes and then stop short. By cranking again she starts up promptly at a good speed, and will then run about half as long as at first, and then die. From this on it is constant cranking and going dead at more frequent stages, until she refuses to go at all. We are using a jump-spark and get a good, lively spark. We also filter our gasoline through a chamois skin, and it is conducted to the engine through brass pipes and brass fittings.

Your trouble is evidently due to a weak battery. Place in the launch a six-volt battery, such as those that are made for automobiles, and we feel quite certain that your trouble will disappear.

* * *

I have recently designed a horizontal engine 8½x15 inches, which runs at 230

r. p. m. The engine is of the throttling type, and its fuel consumption at its rated load of 15 B. H. P. is 23½ gallons of gasoline per day of ten hours. The vaporizer is as shown in accompanying illustration. The gasoline is pumped to a small constant reservoir, from which it is drawn by the suction of the air from a



gasoline valve at C and an air valve at D regulates the amount of air. The mixture is throttled by a butterfly valve between the vaporizer and the inlet valve of the engine. Will you kindly suggest a way to cut down this fuel consumption?

The trouble is due to a peculiarity of this type of vaporizer. The proportion of gasoline in the air increases with the speed of the air current by the gasoline nozzle. For instance, if the air valve and gasoline valve are both set so that the engine gets a good mixture when operating at its minimum load, the mixture will be too rich when the throttle is wide open. The remedy for this is to attach a poppet valve on part of the air passage to the gasoline nozzle, so that, as the draft of air increases the poppet valve will be opened against a spring and let in air directly to the engine without passing in by the gasoline nozzle. The poppet valve should be extremely light and the movement very small, and so constructed that the spring is adjustable. It is usual to make the area of the opening such that the opening around the nozzle is one-third of the total inlet area, and the opening of the by-pass valve is two-thirds.

* * *

(a) The igniter points of our 20 H. P. gasoline engine burn out in about three or four months. We use five cells of Edison's primary type R. R. Our igniter is on top of the cylinder in a small hood bolted to the cylinder, and is not cooled except by the surrounding air. It is a make-and-break spark. The platinum alloy points are brazed and are flat points.

being ⅛-inch in diameter at the points. These are in contact about 90 degrees in a revolution. They are covered with small beads or globules and the electrode burns hollow. Then I have to emery it again to get a good spark. Of course this is very expensive and undesirable. I have tried changing the direction of the current every few days, but it does no good. The engine is overloaded at times and the hood gets quite hot. Can you suggest a way to overcome this difficulty? (b) Another point I wish to ask about is misfires. Our load varies considerably and when the engine is set to run smoothly with full load I find that when the load is light the first charge after it has cut off two or three impulses will not explode and the next time will be a heavy explosion. This will stop it if I turn on a little more gasoline when the engine is next thrown on, but the engine does not give as much power as before. This requires a change in the fuel valve quite often.

(a) The method of locating the igniter in a pocket is the poorest practice imaginable. In the first place, no electric igniter should be set in a pocket. You might overcome your troubles by using "casalloy' or "meteor wire" 3-16 inch diameter for your points, but we doubt it. We suggest that you put a plate on instead of the hood. Tap the plate with a

1½-inch pipe tap, secure a mica plug with platinum points and use jump-spark ignition. See that the spark points of the plug extend well into the compression space. Of course, if the small hood you speak of is required for other purposes it will be impractical to change it. In this case drill through into the cylinder wall, and if necessary to pass the water jacket, you should use a stud large enough to allow the opening for the plug, making sure that the points project into the cylinder, and do not put your igniter plug in a pocket. (b) We believe that the change in position of the igniter will overcome the difficulty with the misfires. If not, the vaporizer is at fault.

* * *

My two-cycle engine, when running at a high speed, sometimes fires back into the crank-case through the transfer port. The deflector on top of the piston is of cast iron ¼-inch thick. Would it be better to make a deflector of the sheet metal and rivet it onto the piston?

(a) Crank-case explosions are due either to a weak mixture or late ignition. Turning on more gasoline or advancing the spark lead will stop the crank-case explosions. Do not change the deflector, as a thin deflector would get hot and give premature ignition.

I noticed the inquiry about crank-case explosions. (See page 262.)

I have had the same trouble on a 1½ H. P. two-cycle engine when running at high speed, and stopped it by placing a fine mesh screen in the transfer port. Explosions were caused by weak mixture which did not burn fast enough and when the port was uncovered the explosions resulted.

* * *

(a) We have a 6½-inch by 9-inch four-cycle engine running at 240 r. p. m. which the makers claimed to be 5 H. P., but from which we can get only 15 amperes with a dynamo whose fields take one ampere, from which we figure the engine develops only 2½ H. P. (b) Please state what should be the diameter of each valve and also their lift? (c) What should be the dimensions of the compression space? What would be the result if we bolted a plate ½-inch thick on the back of the piston? Would it endanger the crank-shaft by reason of increased compression and greater velocity?

(a) Not knowing the voltage which is given off by your dynamo we can not tell you whether your figures are right or not, but it must be remembered that the efficiency of a small dynamo is very low, indeed, quite often being but 5 per cent. In this case your engine would be developing the full power claimed for it, but it

will not give much over 5½ H. P. on natural gas, and is doing fairly well if it gives 5 H. P. (b) According to your figures the valves should be 1 11-16 inch diameter for the inlet and 1⅞-inch diameter for the exhaust. The valve lift should be ¼ the diameter. (c) The compression space should contain 90 cubic inches, but not knowing the exact shape of your cylinder from the sketch submitted nor the volume of the valve chamber we can not tell you just exactly what the length should be. (d) Bolting on a ½-inch plate would increase the initial pressure, and unless your crank-shaft is unusually strong it may twist it or break your connecting rod. We think the best way for you to tell what your engine is doing is to make a brake test with a prony brake. If it does not develop 5 H. P. there is a deficiency somewhere.

* * *

I have adjusted the vaporizer of my 3 H. P. two-cycle marine engine so it shows a blue flame at the relief cock in the dusk of the evening. When I stop, I switch off the current and then close the cock in the gasoline pipe, the fuel valve remaining untouched. I land, drag in the boat, turn on the current, open the gasoline cock and at the first explosion the engine starts; with the third explosion in the cylinder the fourth charge is ignited in the crank-case when the inlet port is uncov-

ered, I hold that the crank-case ignition is due in this case to the excess of fuel in mixture on the third charge. Am I right, if not, why?

This is the first time we ever heard of surplus of gasoline causing crank-case explosions. Usually they come from a weak mixture or too late ignition. Possibly if you have an igniter with variable lead your engine speeds up in the first three revolutions to make the lead too late and causes the crank-case explosions, or it may be that for some reason the first few explosions empty the crank-case and that the speed of the engine is not sufficient to draw in a good mixture.

* * *

I have a three-cylinder 4½x4½-inch 12 H. P. engine, 900 r. p. m. The cams for the exhaust are on top of engine and exhaust pipes on side with the intake valves next to the spark, plugs on opposite side of exhaust. It seems to be impossible to get it to run longer than five minutes at a time. Sparks and coil are all right, but am using a King commutator and a Turner carbureter, 1-inch opening. Can you tell me where my trouble lies? This engine is in a boat.

It is practically impossible to tell what is the matter with your engine with the brief description you give. It will probably take a careful examination of the engine by an expert to determine where

your trouble lies. It may be that the valves cause it, or it may be improper lubrication, perhaps a weak battery or loose connection improper adjustment of carbureter or poor circulation of water.

* * *

We have received an inquiry and sketch describing trouble the inquirer has with a peculiar igniter on a two-cycle engine. The igniter is of the piston operated variety, the points being separated with the deflecting plate, which strikes the end of the movable electrode. He says of this engine: "I can start the engine up and it will jump right off and run for about half an hour, starting to slow down, and sometimes stops and gives me trouble in the middle of the river. I do not think it could be the gasoline, or it would not start so promptly. I notice the water jacket gets so hot I can just touch it. I also think my trouble is due to the igniter, as I notice when I examine the points that they are broken off. I use ⅛-inch stove rivets with 1-16-inch silver brazed on the head. After I put in new rivets the engine will run again for half an hour. She races like the mischief. Will you kindly advise me what is the trouble, and whether you think I can make the engine better by operating the igniter from the pump?"

In the first place, the engine gets hot either because the piston is too tight or the circulating pump is not operating properly. For an engine of this size (2½ H. P.) the

overflow will be a stream about as big as the forefinger, and the water should never be boiling. Stove rivets are very poor things for igniter points, for the reason that they are soft and will hammer down. Platinum is used a great deal, but large copper rivets, say ¼ inch diameter, will answer if your igniter does not hammer too hard. We know that this is soft, but it has been used successfully. We believe you can make the igniter operate better by working it from the outside by means of the pump eccentric.

* * *

A friend of mine and I had a dispute. He says that if you put a 3 H. P. engine in a 20-foot boat with a 15-inch wheel, and then put the same outfit in a 35-foot boat then the engine will still go at the same speed, but the boat would go slower, and there would be no more wear and tear on the running parts. He also says that a 12 H. P. engine with 24-inch wheel which is run in a 35-foot boat will run the same speed when tied to the wharf as when running wide open on the river. I would like to have your opinion on this matter.

Under the same conditions the engine would not speed up with a bigger boat, provided she was on the same lines as the small one. If the resistance was the same on both boats as might be obtained by making the smaller boat with very bluff lines, and the larger boat with very fine lines, the en-

gine would make the same speed and would drive the larger boat at the same speed as the smaller boat. As to running the engine at the same speed with the boat tied up at the wharf, the engine will run slower, provided the screw propeller is the same. Watch your friend, in case he has a reversible propeller, that he does not put it at part pitch, or, in case he has a clutch, that he does not slip the clutch. Under the same conditions we are quite sure you will find the engine will run with less revolutions tied up at the wharf. Try it yourself first and see.

* * *

On starting my engine it does considerable smoking at the muffler, does not seem to fire every charge properly, runs for a while, when it commences to make an awful loud report from the exhaust muffler, also seems to check, or lose speed. Can you tell me the cause, also the remedy? The engine is a pumping engine and works all right except the exhaust. It does not carry a very heavy load. Any information you can give me will be appreciated.

This looks very much like a weak battery. It may be due to poor mixture. The exhaust explosions are always caused by misfires.

* * *

I have an automobile in my shop. I have been putting in a new shaft, but the engine does not have power enough. The com-

pression is very good, the engine starts easy. When I open the carbureter the engine slows down instead of speeding up. The spark seems good. I have changed batteries. It used to be a powerful car. I timed the cam to open exhaust as it is going over the center, the intake the same.

We think perhaps the best thing for you to do would be to get an automobile expert to look the machine over. The trouble is probably in the carbureter. If the machine gets too much gasoline when it is opened adjust the needle valve. If it gets best results at high speed, make the point of the needle sharper.

* * *

I have a two-cycle gas engine, 4½x4½ inches on a launch. I sent this engine to a machine shop and had the cylinder bored and a new piston and packing rings put in, and since then I can not get it to run. It will make a few revolutions, then explode in the base and stop. There are two packing rings on top end of piston, but none on the lower end. The machinist that repaired this engine says it is not necessary to have a ring on the lower end of the piston, but I think it is. The piston is a little smaller in diameter than the bore of the cylinder, and I think it is possible that when the piston is on its upward stroke that some of the exploded charge would be drawn in the base, and

that is what causes the explosions in the base. Please let me know whether I am right or not.

One of the most important things in a gas engine is the fit of the rings and the piston. The rings especially should bear all around the bore of the cylinder and against the sides of the grooves. There should be at least three rings at the top of the piston, but none at the bottom. These rings should require at least 18 pounds pressure to force them together to the size of the cylinder. The piston should be a snug fit in the cylinder, so that it can just be pushed through by hand. Your explosions may be due to leaks, weak mixture or late ignition.

* * *

We have a 6½ H.P. gasoline engine of the two cycle type, with a rotary valve in the crank case. We have had quite a little trouble with this engine in cold and wet weather when starting up. We would try different mixtures, and would eventually get one or two explosions, followed by an explosion in the crank case, when the engine would stop. After working with it in this way for an hour we would finally get it running. How can we prevent these explosions in the crank chamber?

Explosions in the crank case of a two-cycle engine are usually due to a weak mixture. In wet or cold weather it is

often a difficult matter to get the gasoline to vaporize properly, particularly when the engine is cold. Warming the air which enters the cylinder will prevent this trouble to a certain extent, but the better way is to warm the engine cylinder. This may be done most readily by filling the water jacket with boiling water. The hot water may be pumped through the bilge connection, but it would be more convenient to tap into the jacket near the top and fill by pouring the water in. The regular pump connection should be shut off until the engine has run about five minutes.

* * *

I have a 1 H.P. gas engine which I use to operate a 500-watt dynamo. The engine governs on the hit-or-miss principle, holding the exhaust valve open when there is no power stroke. The engine will not run the dynamo without considerable flicker of the lights, and I should like to know how to secure greater steadiness of speed.

The only way to secure a steadier light without altering the engine to a throttling governor is to increase the fly wheel. This can be done by putting a fly wheel on the dynamo shaft, or belting from the engine to a jack shaft, and thence to the dynamo, and putting a fly wheel or heavy disk on the jack shaft.

I have a two-cycle marine engine which will stop as soon as I attempt to slow it down, unless I change the gasoline needle valve. Is there a remedy for this that will allow me to vary the speed with the throttle between reasonable limits without changing the needle valve?

There are two solutions of this problem. One is to use an igniter with a variable lead, and the other is to add to the vaporizer an auxiliary air port. This extra opening should be provided with a shutter which is held closed by a light spring or by gravity, and which is opened by the increase in the draft of the air as the speed increases. It may as well be pointed out that a throttle located in the by-pass between the crank case and the cylinder is much better than one placed between the vaporizer and the crank case.

* * *

I have a jump spark coil which occasionally gives a bright spark at the vibrator, and every time it does this the plug will miss fire. Will you kindly tell me the cause of this, and the remedy?

This trouble is nearly always due to either dirt or oil in the vibrator. The remedy is obvious.

* * *

I have a 50 H.P. four-cylinder engine, running on a dry cell for starting and magneto for running. If I let the engine

run on the battery very long it begins to misfire, while if I run on the magneto it runs all right. I use 9 cells, which give 11 volts, and I am sure that the connections are firm. On the 6 H.P. I am running the engine misfires on magneto, but is all right on the battery. The magneto shows between 8 and 9 volts and has been cleaned lately, including the brushes and commutator. (a) Can you explain why this is? (b) What is a good rule for temperature of the pipes carrying the vapor to the engine? In my engine they are always very cold and dripping water; others, I have noticed, stay warm. (c) What is the theory of mixing warm air to make gasoline vapor, and can you get more power with warm air or cold air? (d) Can more power be obtained from a gasoline engine using a jet feed than with a vaporizer? (e) My engine is a four-cycle, four-cylinder, 9x13 inches, with suction inlet valve and vaporizer and spark shifter. What power could this engine develop at the proper speed, and what speed would you call correct? What size wheel should this engine turn on an 86-foot boat with a 12-foot beam, 4½ foot draft, the boat having a torpedo stern, and what should be the speed of the propeller? (f) At present the engine is turning a 42x60 three-blade propeller at 275 r.p.m. Do you think it would do better with a smaller wheel?

(a) The performance of the engine shows that it is drawing too fast on the battery and polarizes it. That the other engine does not run well on the magneto is apparently the fault of the magneto. (b) Generally speaking, it is better not to warm the air going into the vaporizer. However, in exceptionally cold weather, and when the humidity or amount of moisture in the air is great, it assists in starting the engine. (c) An engine will give more power on cold air than it will on warm air, for the simple reason that more oxygen is taken into the cylinder. (d) Usually the vaporizer will give a better performance than a jet feed. However, this depends entirely upon the design. (e) An engine of this size should develop about 55 B.H.P. at 275 r.p.m., which is a fair speed, though it might be possible to make the engine run successfully at 300 r.p.m. (f) It would seem that the present wheel is about right for the engine, although it would probably do no harm to try a finer pitch. The choice of a wheel depends not only upon upon the power and speed of the engine, but upon the lines of the boat. We should say the boat was doing very well for its size by making 11 knots.

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